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THE UNIVERSITY OF ALBERTA

Middle Devonian Stratigraphy North of the Pine Point Barrier Complex, Pine Point, Northwest Territories

by

Julie Ann Lantos

A THESIS

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Abstract

During the Middle Devonian, a major carbonate barrier complex was developed along the northern margin of the Elk Point Basin. Active growth of the barrier (the Pine Point Barrier Complex) continued through Muskeg, or "Lower" Sulphur Point time. At this point a regional regression occurred, resulting in a major disconformity.

To the north of the Barrier Complex, in the Mackenzie shelf area, sedimentation continued, uninterrupted, with a thick sequence of calcareous (Buffalo River) shales. This sediment ultimately transgressed the northern edge of the Barrier complex.

This initial transgressive phase culminated, during "Upper" Sulphur Point time, in the development of fringing reefs, on the northern edge of the partially exposed Barrier Complex. This was then followed by a relatively minor regression. A final transgressive phase, of regional extent, and represented by Watt Mountain sedimentation, flooded the area with shallow restricted seas, which persisted until the end of the Middle Devonian.

Conodonts, derived from this sequence, belong to the Middle and Upper *varcus*-Subzones, and thereby indicate a late-middle to late Givetian age. This lends further support to the model of a younger sediment wedge, transgressing the adjacent and underlying Barrier Complex from the north.

Acknowledgements

The writer is indebted to numerous persons, for providing both opportunity, assistance and support, in the execution of this thesis.

Thanks must go, primarily, to Dereck Rhodes, not only for his inspiration and guidance, but most of all, for letting me share in his "North Trend" in the first place.

Thanks also go to Pine Point Mines Ltd., for providing access to drill core and other geological information, for sample shipping and thin section production and, above all, for providing a stimulating work environment.

Whilst at the University of Alberta, I have benefited greatly from friendly advise and discussion with Dr. B.D.E. Chatterton. His assistance with all aspects of conodont biostratigraphy was invaluable, as was his critical review of the text. I am greatly indebted.

Finally, and especially, thanks go to my husband, Etienne, for believing in me and encouraging me to do this thing; for enduring an absentee, and impoverished, student wife; and for moral support during the hard times.

Köszönöm.

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1. INTRODUCTION

1.1 General Remarks.

The Pine Point mining district is located approximately 800 km north of Edmonton, and 60 km east of Hay River, close to the south shore of Great Slave Lake, in the District of Mackenzie, Northwest Territories (Fig. 1). Well known for its extensive lead and zinc orebodies, the area has been extensively drilled in the search for such base metal deposits.

Topographically, the area is essentially flat, with a very gentle slope toward Great Slave Lake. Drainage by streams is virtually non-existent, although the Buffalo River flows northward into Great Slave Lake, on the western half of the mine property (Fig. 2). With such poor drainage, the area is dominated by muskeg swamp, and numerous small ponds. Drainage is, perhaps, further inhibited by the presence of several east-west trending sand and gravel ridges, believed to be ancient shore lines of Great Slave Lake.

The area is blanketed by extensive Pleistocene and Recent sediments, averaging approximately 20 m in thickness. Consequently, outcrop is extremely scarce, and is more or less confined to the lake shore.

1.2 Purpose and Scope.

This study examines the stratigraphy and depositional history of the wedge of sediment lying north of, and eventually overlying, the Pine Point Barrier Complex.

The aim of this thesis is threefold:

1) To accurately describe the constituent rock units within this sedimentary sequence, with specific reference to texture, mineralogy, and palaeontology.

2) To establish the geometry of the sequence, and its relationship with the

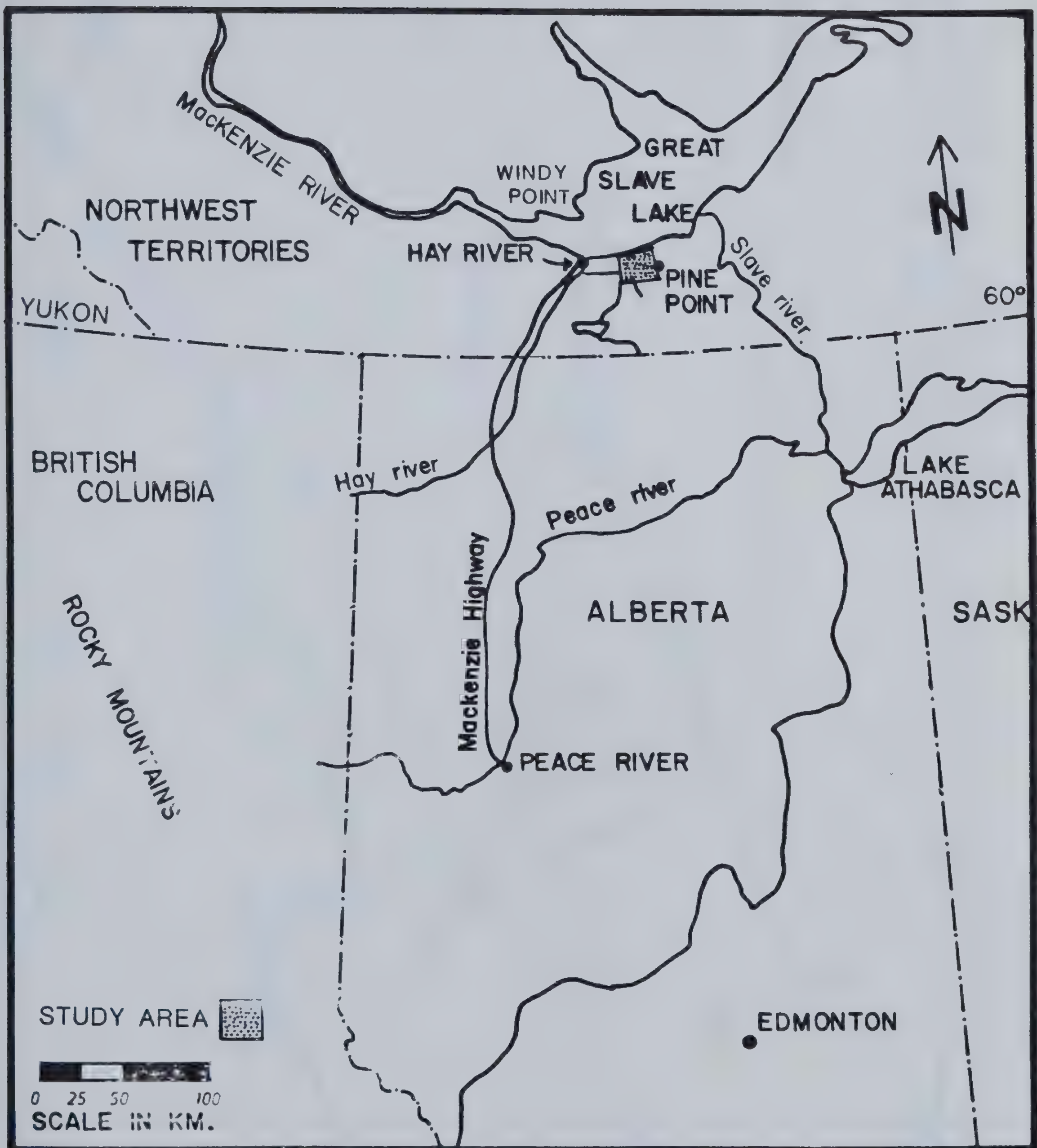

Figure 1. Regional location map.

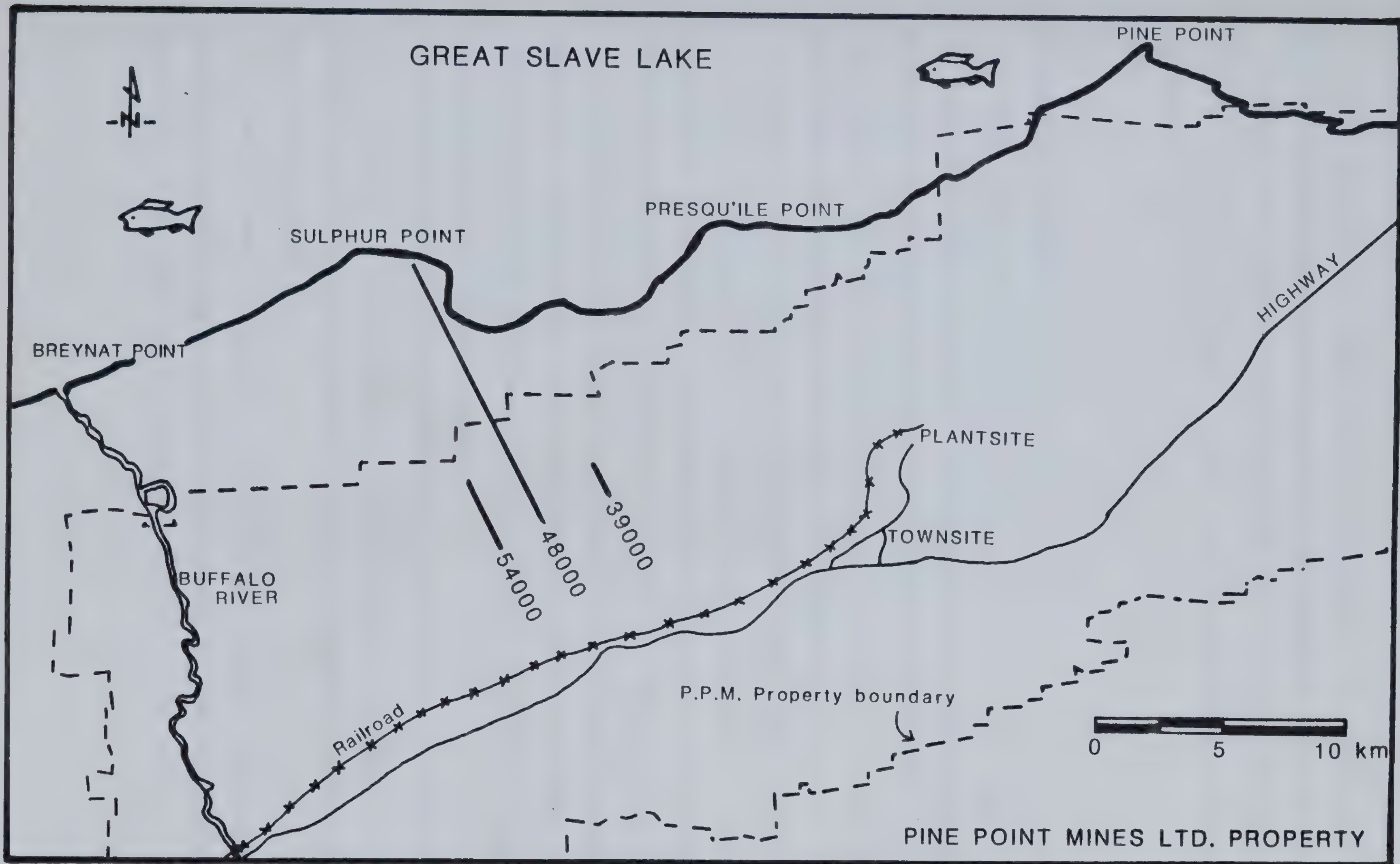

Figure 2. Pine Point Mines Ltd. property map, showing location of cross sections 39000, 48000 & 54000.

Barrier Complex which, together with lithologic and palaeontologic observations, might suggest possible depositional environments, and

3) To determine the biostratigraphy of the sequence, using conodonts (if possible), and thereby, provide the means for future time correlation with both the Pine Point Barrier Complex, and the sediments of the Mackenzie basin.

1.3 Method of Study.

Thirty seven diamond drill holes were selected from the northern third of the Pine Point Mines Ltd. property. The holes were drilled along three fences, all oriented perpendicular to the strike of the Barrier Complex (Fig. 2). All holes were drilled by Pine Point Mines Ltd. The core is currently stored on the Pine Point Mines Ltd. property, and was used with permission.

The core was logged during the summer of 1982, using a lithologic breakdown developed by Pine Point Mines Ltd. geological staff. The breakdown is the result of the study of over 150,000 m of core from this northern portion of the property, some 30,000 m of which the writer has examined.

Representative hand samples were taken from the various lithofacies, and slabbed with a diamond saw. Whilst one half was preserved for subsequent examination and photography, matching halves were thin-sectioned (by Cominco Lab. personnel) and studied petrographically.

Bulk sampling was also carried out for the processing of conodonts. 1.5 m lengths of core were sampled, such that 1-2 kg of sample was provided. Occasionally smaller samples were taken, such that lithologic boundaries would not be violated.

Samples were dissolved in a 10% acetic acid solution. The subsequent residue was separated, using the heavy liquid method, and the resulting heavy fraction was hand picked for conodonts.

1.4 Previous Work.

The Pine Point area has been the subject of study ever since 1898, when prospectors discovered base metals, whilst journeying to the Yukon.

Most studies have concentrated on the Barrier Complex itself, which, in terms of relationship to ore, is naturally of more interest. Studies of a broader scope have occasionally been undertaken. However, it is only in the last four years that extensive drilling (over 3,000 diamond drill holes) north of the Barrier Complex has allowed for a detailed understanding of this area. Prior to 1979, drill hole information was relatively sparse, rendering an accurate stratigraphic interpretation difficult.

Campbell (1950) first proposed the name "Buffalo River Formation" for the shale unit encountered in two drill holes which collared near the mouth of the Buffalo River. In 1957 he described 50.3 m of grey-green shale, encountered in Cominco Test Hole G-4 (near Sulphur Point), and redefined the interval as the Buffalo River Shale Member of the Pine Point Formation.

Norris (1965) raised the upper boundary of the Buffalo River Member in D. D. H. G-4 to include approximately 2.0 m of brown limestone, overlain by a further 4.1 m of shale. He then defined this interval as the type section of the Buffalo River Member of the Pine Point Formation. He correlated the member with 50.3 m of grey, shaly limestone, intersected in a drillhole on the northwest side of Great Slave Lake. He further suggested equivalence with 140.3 m of the "Fine-grained Dolomite Member" of the Pine Point Formation, intersected in D. D. H. G-1, east of the Pine Point property.

Belyea (1971) attempted to correlate the Buffalo River shales, and underlying Bituminous Limestones, with the Horn River Formation of the northern flank of the Tathlina Uplift.

Skall (1975), in his landmark paper, described in some detail the stratigraphy of the Pine Point region, paying specific attention to the barrier facies. With certain modifications, it is his classification, interpretation, and nomenclature, which is still in use at the mine. He referred to the Buffalo River Member as G facies, and assigned it, along with facies B through K, to the

"Pine Point Group". He extended the G–4 intersection to a thickness of 59.2 m, and assigned the 2.0 m thick brown limestone, found near the top of the interval, to B (off–reef) facies. He suggested that the Buffalo River shale, or G facies, was intercalated with the barrier facies, and was eventually replaced, from the south, by facies B (Fig. 3).

Since 1975 there has been extensive drilling north of the Barrier Complex, in which the Buffalo River Member has been intersected. Such drilling has revealed that the Buffalo River not only overlies the off–reef facies, but also the fore–reef and reefal facies of the Barrier itself.

Former property geologist D. Adams, in his unpublished Cominco report (1977), was probably the first to suggest that G facies might have been deposited following a period of subaerial exposure of the Barrier Complex, and P. Rasmussen, in her unpublished B. Sc. thesis (1981), concurred with this analysis. D. Rhodes, another Cominco geologist, established the first lithofacies breakdown for the Buffalo River Member, to which this work largely adheres (D. Rhodes, unpubl. report, 1980).

No stratigraphic analysis of the "Upper" Sulphur Point Formation exists in the literature. Norris (1965) briefly described the interval in D. D. H. G–4 (immediately overlying the Buffalo River Shale Member). He mistakenly, yet somewhat understandably, correlated the unit with the uppermost, reefal, facies of the Barrier Complex (referred to, in this thesis, as the "Lower" Sulphur Point Formation), and assigned it as the type section of the Sulphur Point Formation.

Skall (1975) discarded the term Sulphur Point entirely, and assigned the interval to the B (off–reef) facies of the Pine Point Formation. He believed it to be a northern extension of the barrier facies, and, like Norris, to be stratigraphically equivalent to the uppermost reefal and back–reef, lagoonal, facies of the Barrier Complex.

Law (1955) was the first to record the Watt Mountain Formation in the Pine Point area. He recognized the interval, from the base of the Amco shale, down to the top of the "Presqu'ile" dolomite, as belonging to the this formation, and correlated it with his type section, in California Standard's Steen

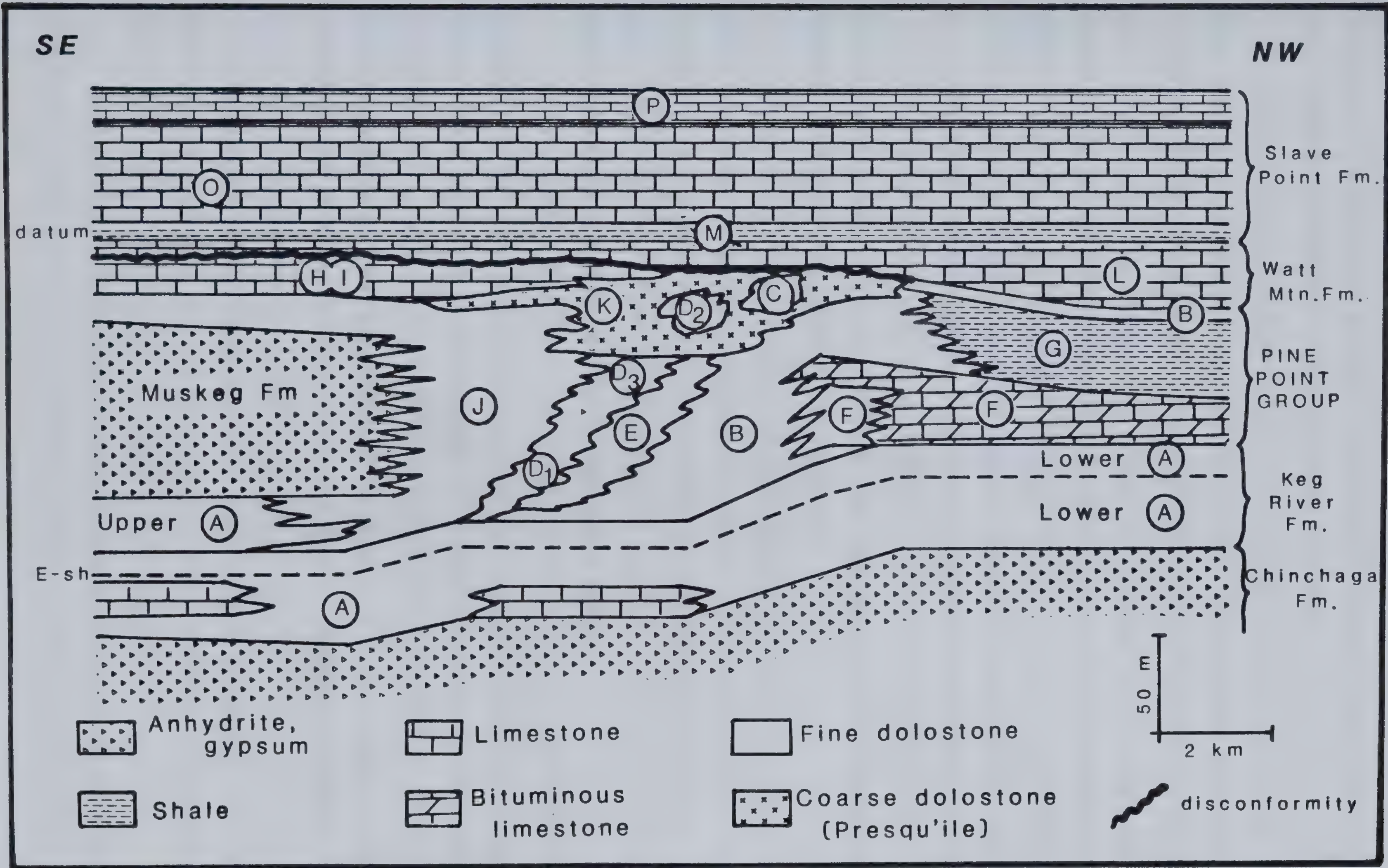

Figure 3. Geologic section, Pine Point Barrier Complex (Skall, 1975).

River 2-22-117-5W6 well. In this type locality, 290 km to the southwest of Pine Point, the formation overlies the Muskeg Formation, and is overlain by the Fort Vermillion Member of the Slave Point Formation.

Campbell (1950) grouped the Watt Mountain Formation with what are now referred to as the Slave Point and "Lower" Sulphur Point formations, and named the entire sequence the Slave Point Formation. By 1957 he had placed this formation into the Great Slave Group, and referred to the Watt Mountain Formation as the "charophyte zone". He used this zone as a stratigraphic marker, defining the top of his "Presqu'ile Member" (today's "Lower" Sulphur Point) at the first occurrence of charophyte oogonia. Similarly, he defined the base of his "Slave Point Member" at the top of the uppermost charophyte bearing bed.

Grayston, Sherwin and Allen (1964) correlated the Watt Mountain Formation of northern Alberta with the First Red Bed unit of Saskatchewan and Manitoba (overlying the Dawson Bay Formation).

Richmond briefly described the Watt Mountain Formation in the Great Slave Lake area, in his unpublished Ph. D. thesis (1965) on the Slave Point Formation. He referred to it as 40 to 60 feet of carbonate, limestone breccia, green shale and charophyte-rich limestone, overlain by 11 feet of dark grey shale/argillaceous limestone, known as the Amco Shale.

Norris (1965), however, was unable to recognize the Watt Mountain Formation in the Pine Point area, and assigned Law's Watt Mountain to the Sulphur Point Formation. In this respect, he included 29.0 m of Watt Mountain Formation (6.0 - 35.0 m, in D. D. H. G-4) with his type section of the Sulphur Point. His confusion was due, no doubt in part, to the fact that the basal contact of the Watt Mountain north of the Barrier Complex changes in character, from non-conformity to conformity.

Hriskevitch (1966) recognized the Watt Mountain Formation from the Rainbow area, overlying the ("Lower") Sulphur Point Formation, and overlain by the Fort Vermillion Member of the Slave Point Formation.

McCamis and Griffith (1967) also recognized the Watt Mountain Formation in the Zama area, overlying their Bistcho member of the Muskeg Formation.

In 1967, Kramers and Lerbekmo also described the Watt Mountain Formation. They were working in the Mitsue–Nipisi area, southeast of Peace River, where the formation includes the Gilwood Sandstone Member. Here, the formation is again overlain by the Slave Point Formation, and is underlain by the Muskeg Formation.

In his unpublished M. Sc. thesis, Wiley (1970) described the Watt Mountain Formation from the Pine Point area, and divided it into four biotypes and eight lithotypes. He recognized the interval to be a transgressive sequence and described its unconformable contact with the underlying barrier facies, but was unsure of stratigraphic relationships north of the Barrier Complex.

Skall (1975) also recognized the Watt Mountain Formation in the Pine Point area, and defined it as his L (Green Shaly) facies. He concurred with Wiley's evaluation of the interval, and hinted at the variable stratigraphic relationship of the unit, resulting from the partial marine regression which occurred prior to its deposition. Skall redefined the upper contact of the Watt Mountain Formation somewhat, excluding the thin, stromatoporoidal limestone, found immediately beneath the Amco Shale, and referred to as the M3 facies of the Amco Member of the Slave Point Formation.

Since 1979 the Watt Mountain Formation (especially in the vicinity of the northern edge of the Pine Point Barrier Complex) has been studied by the writer, and a new stratigraphic breakdown devised (J. Lantos, unpubl. report, 1981a).

Very little biostratigraphic work has been undertaken in the Pine Point area. Norris's work remains not only the most detailed, but virtually the only study to date. Skall did quote some biostratigraphic information in his 1975 paper, but this would seem to have been drawn, primarily, from the more regional work of Braun.

2. GEOLOGICAL SETTING

In the vicinity of Pine Point the Pre-Cambrian basement is non-conformably overlain by approximately 430 m of relatively undisturbed Palaeozoic sediment. A gentle regional dip of approximately 1.9 m per km results in progressively younger sediment subcropping toward the west. The erosional edge of these Palaeozoic strata is located 100 km to the east of Pine Point.

The oldest Palaeozoic sediments here are the basal red beds of the Mirage Point Formation (Norris, 1965). On the basis of inferred stratigraphic position an Ordovician or older? age had been assigned to this formation. Belyea (1971) suggested that these sediments might be as young as Lower Devonian in age. The Mirage Point Formation is overlain by dolomites and anhydrites of the Ernestina Lake Formation (Sherwin, 1962), followed by red beds and salt of the Cold Lake Formation (Sherwin, 1962). These, in turn, are overlain by evaporites of the Lower Chinchaga Member (Belyea, 1971) of the Chinchaga Formation (Law, 1955). The Ernestina Lake and Cold Lake Formations and the Lower Chinchaga Member together comprise the Lower Elk Point Sub-group (Belyea, 1971), and were deposited in the Southern Mackenzie Basin – one of three distinct sub-basins which comprised the Lower Elk Point Basin at this time, and which slowly expanded, and subsequently merged, to form a single basin at the beginning of Upper Elk Point time (Grayston et al., 1964). Palaeontological data are sparse : however, on the basis of that little information available (Crickmay, 1954, Norris, 1965, Belyea and Norris, 1962, Belyea, 1971) and on stratigraphic position, a lower Middle Devonian, or Eifelian, age is generally accepted for the Lower Elk Point Sub-group.

The Upper Chinchaga Member is separated from the Lower Chinchaga Member by an erosional unconformity (Belyea, 1971). It is the oldest member of the Upper Elk Point Sub-group, and consists primarily of anhydrite, with basal shales. No fauna has ever been recorded from this formation, nevertheless an

Eifelian age is generally assumed.

The Chinchaga Formation is immediately and conformably overlain by the Lower Keg River Platform Member (Hriskevitch, 1966; Skall, 1975) of the Keg River Formation (Law, 1955). This was not recognized as a separate formation by Norris, in his report on the area, but appears to correspond to his Limestone Member of the Pine Point Formation (Norris, 1965). The unit maintains a constant thickness of approximately 65 m in the Pine Point area, and hosts a diverse fauna, typical of an open marine platform environment. Skall (1975) suggested that an early Givetian age was indicated, on the basis of the fairly rich ostracod fauna. Braun (1978), however, placed the ostracod fauna into his lower DM 5 sub-assemblage, and suggested an upper Eifelian age. A Middle Devonian age is, at the very least, indicated, based on the overall faunal assemblage, and more especially on the presence of *Atrypa arctica* Warren (Norris, 1965).

The presence of such open marine platform carbonates immediately, and quite sharply, overlying the Chinchaga evaporites, is indicative of a sudden change in environmental conditions, presumably the result of a sudden and widespread marine transgression, which can be recognized throughout the Elk Point Basin. Such a widespread transgression is believed to be the result of regional subsidence, rather than eustatic sea level rise (Basset & Stout, 1968). Deposition of the Lower Keg River Platform Member presumably occurred during the "Platform time" of Bebout and Maiklem (1973), or the "Lower Keg River time" of McCamis and Griffith (1967). Elsewhere in the Elk Point Basin, the Keg River Formation is recognized as that carbonate unit lying above the Chinchaga evaporites, and is frequently overlain by yet another thick sequence of evaporites. It corresponds to the Winnepegosis Formation of Saskatchewan, and toward the northwest is presumed to grade laterally into the basinal shales of the lower Hume Formation (Basset, 1961). This latter formation also contains the lower DM 5 ostracod sub-assemblage of Braun, and an Eifelian conodont fauna (Uyeno, 1979; Chatterton, 1979). The numerous fringing and patch reefs of Upper Keg River time (Hriskevitch, 1966; McCamis & Griffith, 1967) are not

recognized in the Pine Point region, but are the lateral equivalents, in part at least, to the lower portions of the Pine Point Formation (Cameron, 1918; Norris, 1965; Skall, 1975).

The initial shoaling of the Pine Point Barrier Complex (also known as the "Presqu'ile Reef Complex" or the "Presqu'ile Barrier Complex") no doubt began at this time. It developed along the carbonate-shale edge, possibly in response to a subtle arching of the Keg River platform. The development of the Pine Point Barrier Complex extended from northeastern British Columbia, through northern Alberta and into the southern Northwest Territories (Fig. 4). In Pine Point this regional shoaling is marked by the development of the B Spongey facies (Skall, 1975: Fig. 3 of this work) of the Pine Point Formation. This horizon averages 15 m in thickness, and apparently corresponds to the "1st Reef-Mound time" of Bebout & Maiklem (1973). It is on this marine shoal that the various barrier (and equivalent) facies of the Pine Point Formation are developed, as the open marine conditions evidenced by the Keg River, and to a certain extent the B Spongey facies, gave way to shallower water conditions in which more diverse organisms flourished. At a certain point environmental conditions became suitable for the more robust frame building organisms of the D1 lithofacies (Skall, 1975) to flourish. The linear development of this bioherm-like feature resulted in a differentiation of depositional environments, such that the coeval back-reef, subtidal and supratidal J facies (Skall, 1975) of the Muskeg Formation (Law, 1955) were deposited on the southern, or Elk Point Basin, side of the barrier, whilst to the north a "fore-reef" sand (E facies, Skall, 1975) was derived from the D1 lithofacies. Quieter, more open marine conditions prevailed to the north of this, represented by B (marine) facies (Skall, 1975); and even further to the north, the F (pelagic) facies (Skall, 1975) was deposited. These dark, bituminous, F facies limestones apparently represent the most northerly carbonate development at the front of the Elk Point Basin platform edge.

The band of intense biological activity, represented by D1 lithofacies, is a reflection of a narrow tract wherein conditions of water depth, energy,

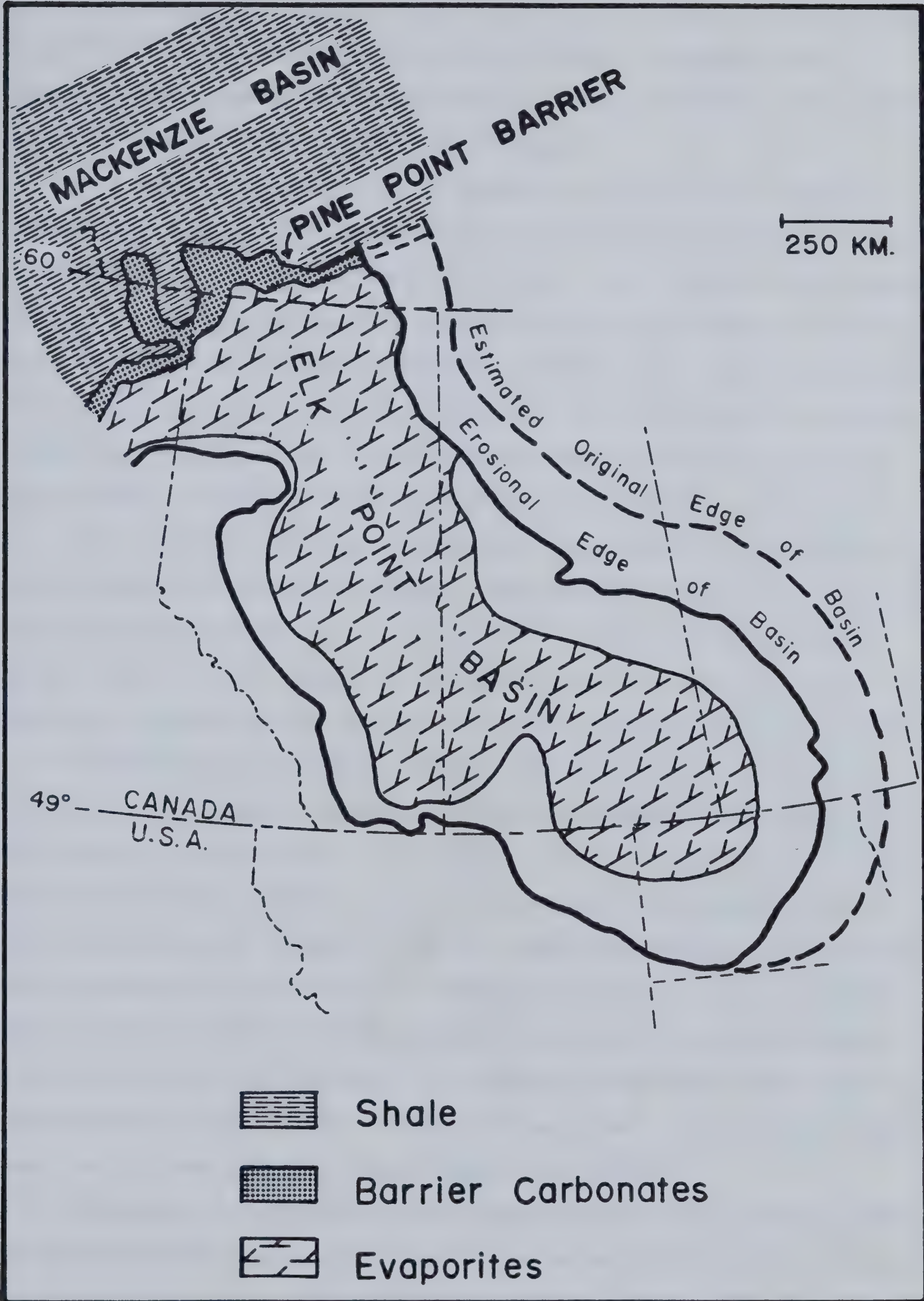

Figure 4. Regional facies distribution map (after Bebout & Maiklem, 1973).

temperature and salinity allowed skeletal organisms to flourish. This zone of high organic activity acted as a factory in the production of carbonate sand (represented by E facies) producing a broad, continuous, carbonate sand bank of low relief, termed the Pine Point Barrier Complex.

The confinement of the Barrier Complex to this area, then, can be viewed more as a result of the relatively inhospitable conditions already in existence everywhere else (too deep to the north, too restricted to the south). Whilst the Pine Point Barrier Complex may well have exacerbated the restricted nature of the Elk Point Basin, its presence should not be viewed as the cause. The extensive and shallow nature of the epeiric sea at that time, the tropical climactic conditions, and lack of any freshening marine influence would, alone, have resulted in elevated salinities and temperatures in the Elk Point Basin.

By the end of Pine Point time, the D1 and E facies had surmounted the marine facies in a northerly progradation, climbing approximately 150 m over a horizontal distance of some 10 km (Figs. 3 & 5). The active growth of the Barrier during this time appears to coincide with the "2nd Reef-Mound time" of Bebout and Maiklem, or with the "Late Keg River time" of McCamis and Griffith.

Palaeontological information from the Pine Point Formation is somewhat sparse, and when available, generally of little biostratigraphic value, due either to long ranges of the species, or poor sample control. *Stringocephalus* sp. molds have been tentatively identified within D1/E facies (roughly equivalent to the "Fine Grained Dolomite Member" of Norris, 1965). Norris further stated that the faunal assemblage of the "Bituminous Shale and Limestone Member" (B Marine facies equivalent), whilst not being particularly diagnostic, is "contemporaneous with beds containing *Stringocephalus* sp. elsewhere in the area, and is dated as Middle Devonian (Givetian) age." Similarly, Skall suggested a middle Givetian age, based on a B (marine) ostracod assemblage (Skall, 1975).

Stratigraphic correlations are notoriously difficult to carry northward into the Mackenzie Basin, particularly in view of the limited biostratigrahic control. Nevertheless, the open marine shales of the Hare Indian Formation (Basset, 1961) are presumed to represent lateral equivalents of the Pine Point Formation.

It is possible, though not documented, that Pine Point time ended with a period of non-deposition, possibly even sub-aerial exposure of the Barrier. Deposition within the Elk Point Basin at this time was characterized by even more restricted conditions, represented by the "Salt and Zama Anhydrite times" of Bebout and Maiklem, or the "Black Creek Salt time" of McCamis and Griffith. By "Early Zama Dolomite time" of Bebout and Maiklem, or "Zama-Rainbow time" of McCamis and Griffith, carbonate deposition was renewed within the basin. At Pine Point, reefal limestones and reefal sands (D2 and C facies respectively, Skall, 1975) of the Sulphur Point Formation (Norris, 1965) developed on the palaeotopographic high formed by the Pine Point Barrier complex. To the south, lagoonal H & I facies (Skall, 1975) of the Sulphur Point Formation were developed (Fig. 3). This deposition was, initially, laterally equivalent to continued subtidal and supratidal conditions prevailing to the south, in the adjacent Muskeg Formation. However with time the lagoonal, and in part subtidal, Sulphur Point Formation prevailed, replacing the Muskeg Formation, and extending far to the south.

It is worth mentioning here that there has been, and still is, considerable confusion about the use of the term Sulphur Point Formation in the Middle Devonian of the Elk Point Basin. This perplexity is rooted in two events. Firstly, Norris' assignment of the interval 6.0-53.0 m, in Cominco Test Hole G-4, as the type section of the Sulphur Point Formation. Unfortunately the G-4 drillhole was drilled far to the north of the erosional/depositional edge of what is now generally recognised as the Sulphur Point Formation. What most other workers have called the Sulphur Point Formation, and what Norris himself, apparently, considered to also belong to that unit, is found to the south of the unit containing the type section, is separate, and overlies both the Barrier Complex and the adjacent Muskeg Formation. Secondly, he established the Presqu'ile Formation, which is now recognized to be a diagenetic feature, resulting in the spectacular recrystallization of, primarily, the unit that occurs to the south and called the Sulphur Point Formation. Because of this, Skall discarded the term Sulphur Point as a valid formation name, and placed his D2, C and

H & I facies in the Pine Point Group. This southern unit (generally referred to as the Sulphur Point Formation) can no doubt be regarded as a stratigraphic equivalent to the Bistcho member (informally proposed by McCamis and Griffith) of the Muskeg Formation, and it is conceivable that this term should be adopted in the Pine Point region. However, for the sake of conformity with the terminology currently in use by Cominco geological staff, and established in the literature, the name Sulphur Point is retained here. In order to avoid confusion, this interval will, henceforeward, be referred to as the "Lower" Sulphur Point Formation. The interval assigned by Norris as the type section of the "Sulphur Point Formation" is, in fact, the biostromal interval discussed in this thesis, and henceforward referred to as the "Upper" Sulphur Point Formation (Fig. 5). It overlies the Buffalo River Member of the Pine Point Formation, is overlain by the Watt Mountain Formation, and outcrops at Sulphur Point (on the south shore of Great Slave Lake). It was from this interval that Norris presumably collected most of his palaeontological data for the "Sulphur Point Formation". It is these same data which form the basis for ages attributed to the "Lower" Sulphur Point Formation (or Skall's D2, C and H & I facies). Such ages must, then, be considered as possibly erroneous.

For a discussion of necessary revisions to the stratigraphic nomenclature of this region, the reader is referred to Chapter 3.2, entitled nomenclature.

The end of "Lower" Sulphur Point time is marked by a period of distinct non-deposition, and sub-aerial exposure of the Barrier Complex including its back-reefal area. This was possibly equivalent to the "Rainbow-Anhydrite time" of Bebout and Maiklem, and it was at this time that karsting of the Barrier Complex is believed to have been initiated, concomitant with the spectacular recrystallization and dolomitization referred to by Cominco geological staff as Presqu'ilization (J. Lantos, unpubl. report, 1981b).

During this period of non-deposition and erosion (specifically, but not exclusively, along the carbonate platform margin), restricted conditions persisted in the Elk Point Basin ("Rainbow-Anhydrite time", Bebout and Maiklem); and marine shale deposition continued in the Mackenzie Basin to the north.

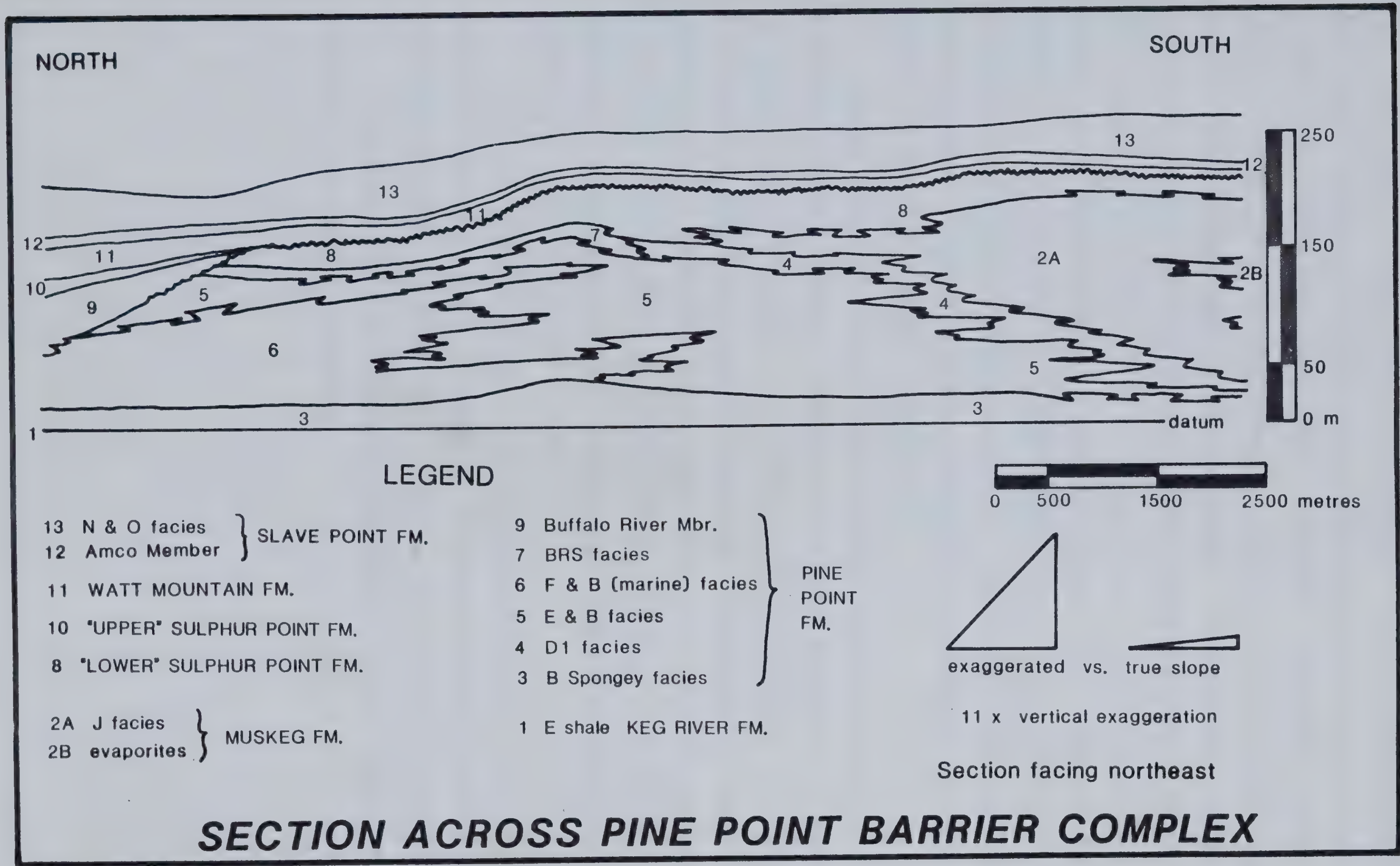

Figure 5. Pine Point Barrier Complex section, modified after Pine Point Mines Ltd. usage.

Deposition of the Buffalo River Member of the Pine Point Formation may have begun as early as Pine Point time, or may not have begun until after "Lower" Sulphur Point time. In any event, the member represents a tongue, generally thought to be laterally equivalent to the Hare Indian Formation shales, which ultimately transgressed the Barrier Complex. This presumably occurred as part of an overall marine transgression which culminated in "Upper" Sulphur Point deposition (the Sulphur Point of Norris). Such a marine transgression appears to be coincident with the "Rainbow Dolomite time" of Bebout and Maiklem. This was followed by another regression (the "Upper Muskeg time" of McCamis and Griffith), and a further period of sub-aerial exposure and erosion. This is generally referred to as the Watt Mountain unconformity, an hiatus which ended with the Watt Mountain transgression.

During Watt Mountain time fairly restricted conditions persisted in the Pine Point area, and regionally. This was followed by a sequence of tidal flat to shallow platform carbonates of the Slave Point Formation. In the vicinity of Pine Point the Slave Point exhibits a layer cake like homogeneity; however, regionally one can recognize distinct facies variations, no doubt as complex as those which occurred during Muskeg/Pine Point time. Toward the base of the Slave Point, and apparently only in the Pine Point mining area, a useful marker horizon, the Amco shale is developed.

The end of the Slave Point (and the Middle Devonian) is marked by a period of uplift and erosion, followed by a complete change in depositional style, represented by the Fort Simpson and Hay River formations (Belyea, 1971).

A compilation of the stratigraphic nomenclature, variously used in the Pine Point area, is presented in Figure 6.

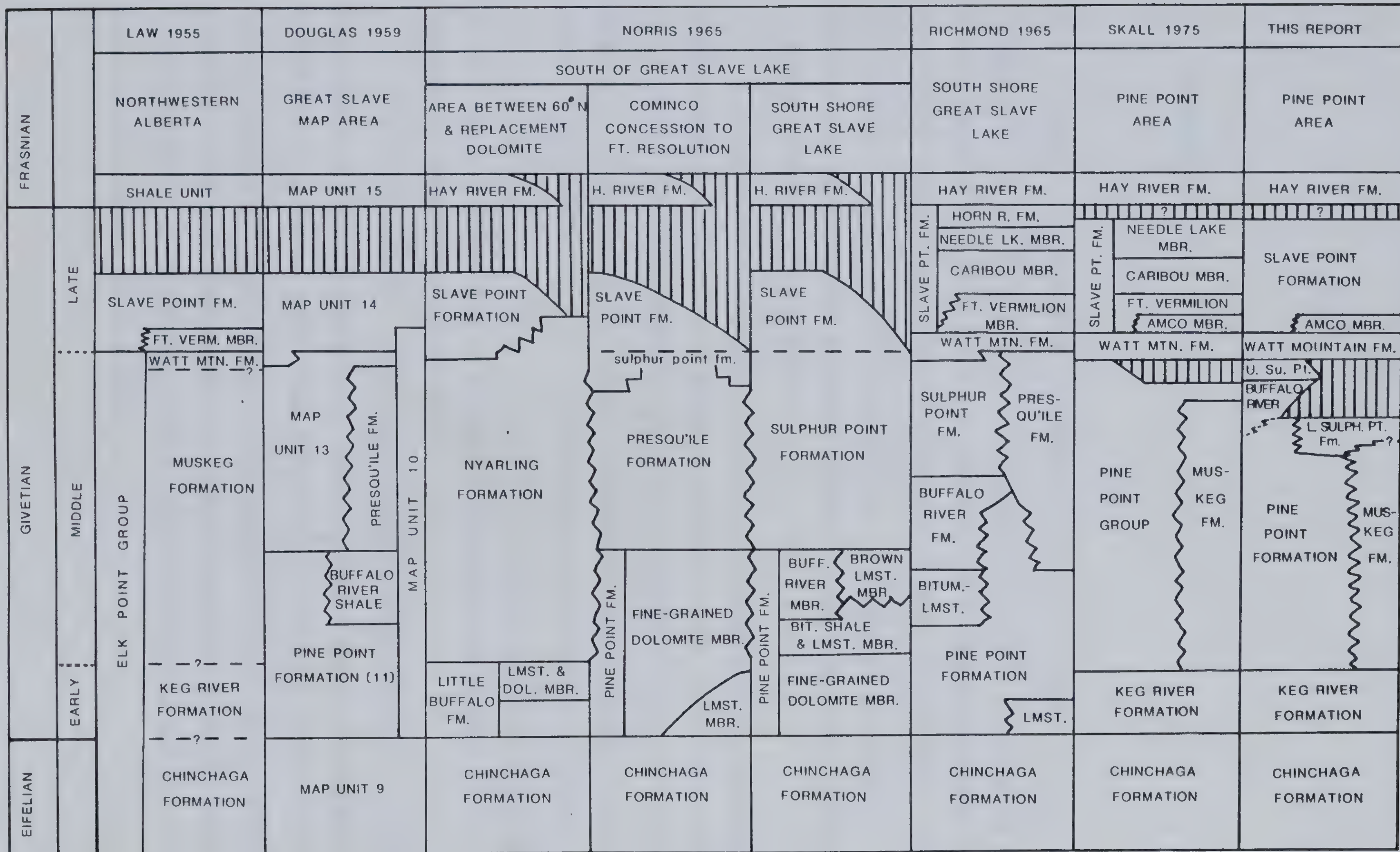

Figure 6. Summary of stratigraphic nomenclature.

3. STRATIGRAPHY AND SEDIMENTOLOGY

3.1 INTRODUCTION

The stratigraphic breakdown proposed herein is the culmination of observations made by the writer, over a period of three years, whilst employed by Pine Point Mines Ltd. It is not, therefore, based solely on evidence derived from the thirty seven drillholes presented in this thesis. Similarly all conclusions regarding depositional environments are also based on this broader observational experience, and are (unless otherwise stated) in accordance with interpretations generally accepted in the literature.

The proposed stratigraphic breakdown is largely based on lithologic features clearly visible in hand specimen (colour, texture, mineralogy etc.). Conclusions regarding environment are variously based on texture, structure (sedimentary or biogenic), biota (type, position, association, diversity, abundance and/or lack thereof) and, to a certain extent, primary mineralogy. Furthermore, every attempt has been made to consider all available evidence, rather than rely on any single criterion, and to pay attention to the overall logic of the depositional scenario thereby involved.

Within the context of this work, the term restricted refers to an environment in which exchange with water of normal marine salinity and temperature was limited. With much of the region covered, during this time, by shallow and tropical epeiric seas, the term generally refers to an environment of higher than normal temperature and salinity. Sediments deposited under these conditions are usually associated with, among other things, a lack of biota or, at least, low diversity of organisms.

Throughout this work, estimations of water depth were based upon sedimentary structure and texture, and to some extent upon biota (algae, for instance, normally exist within the photic zone). In the case of the "basin-filling" shales, overall inferred palaeotopography was also considered.

3.2 NOMENCLATURE

The stratigraphic nomenclature used herein is in keeping with either those terms formally established in the literature, or those terms deeply entrenched in Pine Point Mines Ltd. usage (and informal reporting). This has caused the author to resort to the use of both the terms "facies" and "member", in a manner which may not always be, strictly, taxonomically correct.

The choice of term in each individual case was generally based on numerous, and occasionally conflicting, factors. Included in these would be both status and rank of the unit being subdivided, and the nature and extent of each subdivision. For example, the Buffalo River is, in itself, referred to as a formal member of the Pine Point Formation. This, together with the fact that, within it, certain lithologies may be diachronous, or may be repeated through time, lead to the use of the term lithofacies. The Watt Mountain, however, has been formally designated a formation, and is herein divided into a number of informal members. This is in keeping with the writer's belief that these informal members warrant eventual elevation to formal member status, for they are distinct stratigraphic intervals, not repeated through time, and are of considerable lateral extent.

As mentioned earlier, much of the terminology has been inherited, and conforms to established usage. If and when formal designation is proposed, such terms will, of course, be exchanged for the more proper geographic or descriptive terms.

In this respect it is the writer's belief that the Buffalo River Member of the Pine Point Formation warrants elevation to full formational status, with subsequent division into appropriate, formal, members. Certain of these members will include more than one of the lithofacies recognized in this work, and will not be repeated in time.

Similarly, informally proposed members of the Watt Mountain Formation also warrant formal status.

In view of the considerable confusion with respect to the term Sulphur Point Formation, it is the writer's belief that this term should be dropped entirely and that both the "Upper" and "Lower" Sulphur Point formations be renamed. The "Upper" Sulphur Point Formation can, apparently, be traced across Great Slave Lake to Windy Point; thus the term Windy Point Formation might be a suitable choice. It is the current opinion of the writer that the "Lower" Sulphur Point Formation should be established as a formal member of tha Muskeg Formation, and that this member be assigned a new name.

3.3 THE BUFFALO RIVER SEQUENCE.

Introduction.

The Buffalo River Member of the Pine Point Formation is known only from the subsurface, south of Great Slave Lake. Lying to the north of the Pine Point Barrier Complex, it forms a northward thickening wedge of sediment, composed predominantly of grey-green limy shales. Its southern depositional and/or erosional edge parallels the N65 E strike of the Barrier Complex, as do isopachs. In its type locality (Cominco test hole G-4), it reaches a thickness of some 60 m. This intersection, 9 km north of the pinch-out, illustrates the very gradual thickening of the sediment wedge.

If we can assume that the upper surface of this member represents an horizontal depositional surface, and that its lower surface also represents an

original depositional surface, then we can estimate the basinal slope of the Barrier Complex to be approximately 0.5 , and certainly no more than 2 .

It is a common flaw of cross sections that vertical exaggerations required to encompass geology will result in deceptively spectacular gradients. To this rule, Pine Point is certainly no exception, and may well be a prime example. Figure 7, drawn perpendicular to the strike of the Barrier Complex, schematically illustrates the geometry of the Buffalo River Member, its position relative to the barrier facies, and its northward thickening character. It must be emphasized that the degree of exaggeration used here is extremely deceptive. In actuality this member thickens at a rate of no more than 1:150. The basinal slope, evidenced by the surface of the Pine Point Formation, was extremely gentle, and the Barrier Complex itself was a broad, elongate feature, of low relief.

Palaeozoic strata in the Pine Point area dip very gently toward the west. As a result, the Buffalo River Member has been truncated by erosion to the east of Pine Point, whilst toward the west it is located at ever increasing depths. Not known in outcrop, the interval does, however, subcrop on the Pine Point Mines Ltd. property, and has recently been exposed in the X53 pit on that property. The Buffalo River Member has been reported in drillholes to the west of Hay River, establishing a strike length of at least 100 km. Drilling in the Windy Point area, 100 km to the northwest, suggests that it may extend to the northwest side of Great Slave Lake (D. Adams, pers. comm.).

The Buffalo River Member overlies both the marine and fore-reef facies of the Pine Point Formation, and the reef facies of the "Lower" Sulphur Point Formation. Its relationship to these facies, forming the northern edge of the Pine Point Barrier Complex, is shown schematically in Figure 8. (Note vertical exaggeration.)

To the north, where it overlies the more marine (B and F facies of Skall, 1975) facies of the Pine Point Formation, and where it is developed at thicknesses greater than 20 m, the lowermost unit of the Buffalo River Member

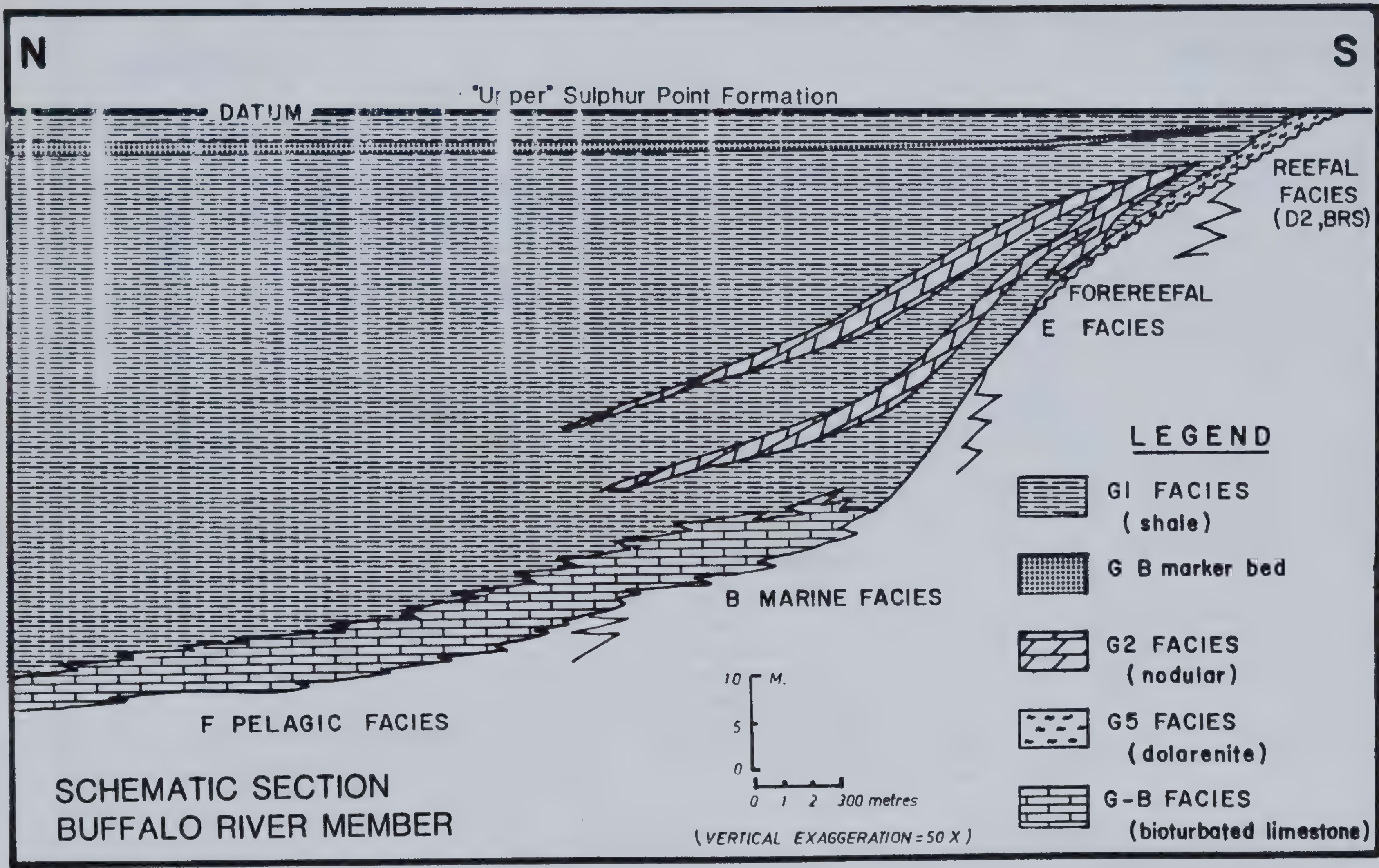

Figure 7. Schematic section, Buffalo River Member, showing lithofacies relationships (modified after Rasmussen, 1981).

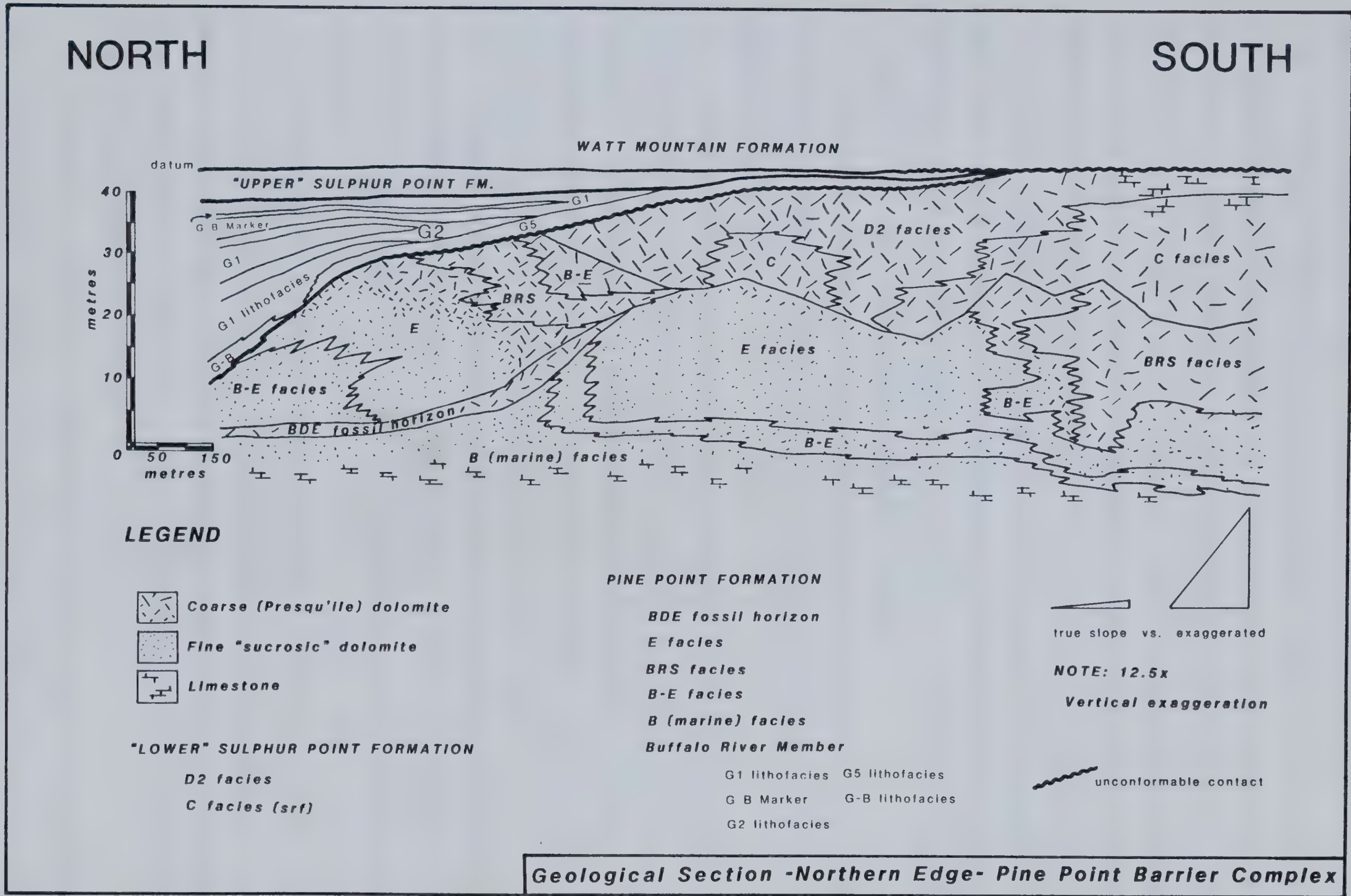

Figure 8. Geologic cross section, showing relationship of Buffalo River lithofacies to underlying Barrier facies (modified after Rhodes, 1980).

is designated G–B facies (described below). It shows an onlapping and gradational relationship with the underlying and laterally equivalent B and F facies.

F (pelagic) facies is a dense, dark brown to black, finely planar laminated, bituminous limestone, characterized by the presence of *Tentaculites* sp. and *Styliolina* sp. (Norris, 1962). It is interpreted as being deposited in a somewhat starved, yet not especially deep, basin. It frequently contains thin interbeds of lighter, less bituminous limestone, containing a more diverse fauna, including brachiopods and crinoids. Such interbeds are interpreted as representing periods of improved oxygenation, rather than any drastic change in sea level. F facies also hosts several thin, coarsely bioclastic beds, completely lacking in fine biomicrite matrix, and which appear to be debris flow deposits of some kind, originating from the actively growing Barrier Complex.

Where F facies is overlain by the Buffalo River Member, the contact is at all times gradational, in terms of both bituminous/argillaceous content, and in degree of bioturbation.

F facies grades both laterally and vertically into B (Marine) facies. Primarily a fine biomicrite, finely bedded, somewhat wispily laminated and rich in bitumen, B facies contains a diverse fauna which includes *Atrypa* spp., *Warrenella* spp., and *Leiorhynchus* spp., abundant crinoid ossicles, and *Tentaculites* sp. (For a more detailed list see Norris, 1962.)

B facies shows a similar relationship to the overlying Buffalo River Member. There is a decrease in both abundance and diversity of fauna, and an increase in both argillaceous content and bioturbation, as the former grades into the latter.

Farther south, where the Buffalo River has thinned to 20 m or less, its lowermost unit is designated G5 facies (described later in this thesis). It overlies both the fore–reef facies of the Pine Point Formation (designated E facies by Skall, 1975), and the reef facies of the "Lower" Sulphur Point Formation (D2 facies of Skall, 1975).

E facies is a clean, fine calcarenite, believed to have been deposited under agitated water conditions, and to have been derived from the D1 (organic

barrier) facies of Skall. It shows a marked lack of argillaceous and/or organic content. It is at all times recrystallized to either a fine sucrosic dolomite, or a coarser, more spectacular form of dolomitization (referred to as Presqu'ilization by Pine Point geological staff.)

D2 facies is a massively fossiliferous unit, with abundant stromatoporoids and corals, and is entirely reefal in aspect. Except where (rarely) preserved as limestone, it is nearly always recrystallized to a coarse, "Presqu'ile style" dolomite.

BRS (biohermal) facies, not separated out by Skall, is also found in this area, and is also overlain by G5 lithofacies. It, too, is a richly fossiliferous unit, but is easily distinguished from D2 by its marked argillaceous/bituminous content, and its somewhat different faunal content. It, too, is frequently "Presqu'ilized".

The basal contact of G5 lithofacies is usually extremely easy to pick for the underlying Barrier facies nearly always show signs of so called "Presqu'ilization". This results in a marked crystallinity change at the contact, for such coarse recrystallization never extends up into the Buffalo River Member.

The contact only becomes somewhat problematical where G5 rests on "un-Presqu'ilized" E facies dolomite. The two lithofacies are very similar in appearance, which is, no doubt, a reflection on their similar source and mode of origin. Nevertheless, the two lithofacies can usually be distinguished, one from the other, with a fair degree of certainty.

One other lithofacies, of the Buffalo River Member, is occasionally found resting directly on the Barrier Complex. It is a grey-green, limy shale, designated G1 facies, and is the most abundant lithology within the Buffalo River Member. It rests sharply, and with apparent disconformity, on E facies.

Whilst difficult to substantiate from core, the basal contact of the Buffalo River Member, specifically where G5 forms the lowermost unit, apparently marks a disconformity. Evidence pointing toward this conclusion will be discussed in greater detail later on in this thesis.

The Buffalo River Member is entirely overlain by a laterally continuous, fairly thin unit, known on the Pine Point property as B Biostromal, and assigned by Skall (1975) to the B facies of the Pine Point Formation. It is this unit, however, which forms the type section for Norris' Sulphur Point Formation, and is referred to, in this thesis, as the "Upper" Sulphur Point Formation (Fig. 9).

For the most part the "Upper" Sulphur Point Formation is a dark brown, dense, finely crystalline, fossiliferous dolomite. The uppermost unit of the Buffalo River Member, in by far the majority of intersections, is the G1 (grey-green shale) facies. Where overlain by the "B Biostromal", the contact is extremely sharp and well defined. Toward its southern edge, where G5 facies forms both the basal and the uppermost unit of the Buffalo River Member, it is overlain by a more richly fossiliferous, "reefal" "B Biostromal". The contact between the two, usually quite well defined, becomes increasingly difficult to recognise as the pinchout of both intervals is approached.

The Buffalo River Lithologies.

The Buffalo River Shale Member is divisible into five lithostratigraphic units. This subdivision is based on lithologic features clearly discernible in hand specimen, largely on the basis of colour, texture, and bitumen/clay content. It is more or less identical, though simplified, to that subdivision currently in use at Pine Point Mines Ltd., and adheres to that terminology (D. Rhodes, unpub. rep., 1980). The breakdown proposed by Rasmussen (1981) is broadly similar, but uses a different nomenclature, which is not adopted here.

The breakdown herein proposed is based not only upon the three fences of holes used to document this thesis (Figs.A, B and C, in back pocket), but also on the extensive drill evidence available from the Pine Point Mines Ltd. property.

Photographs representative of these various lithologies are presented in, Appendix C, Plate 1. Whilst the lithofacies breakdown is based on hand specimen identification, thin sections have been studied, and selected descriptions

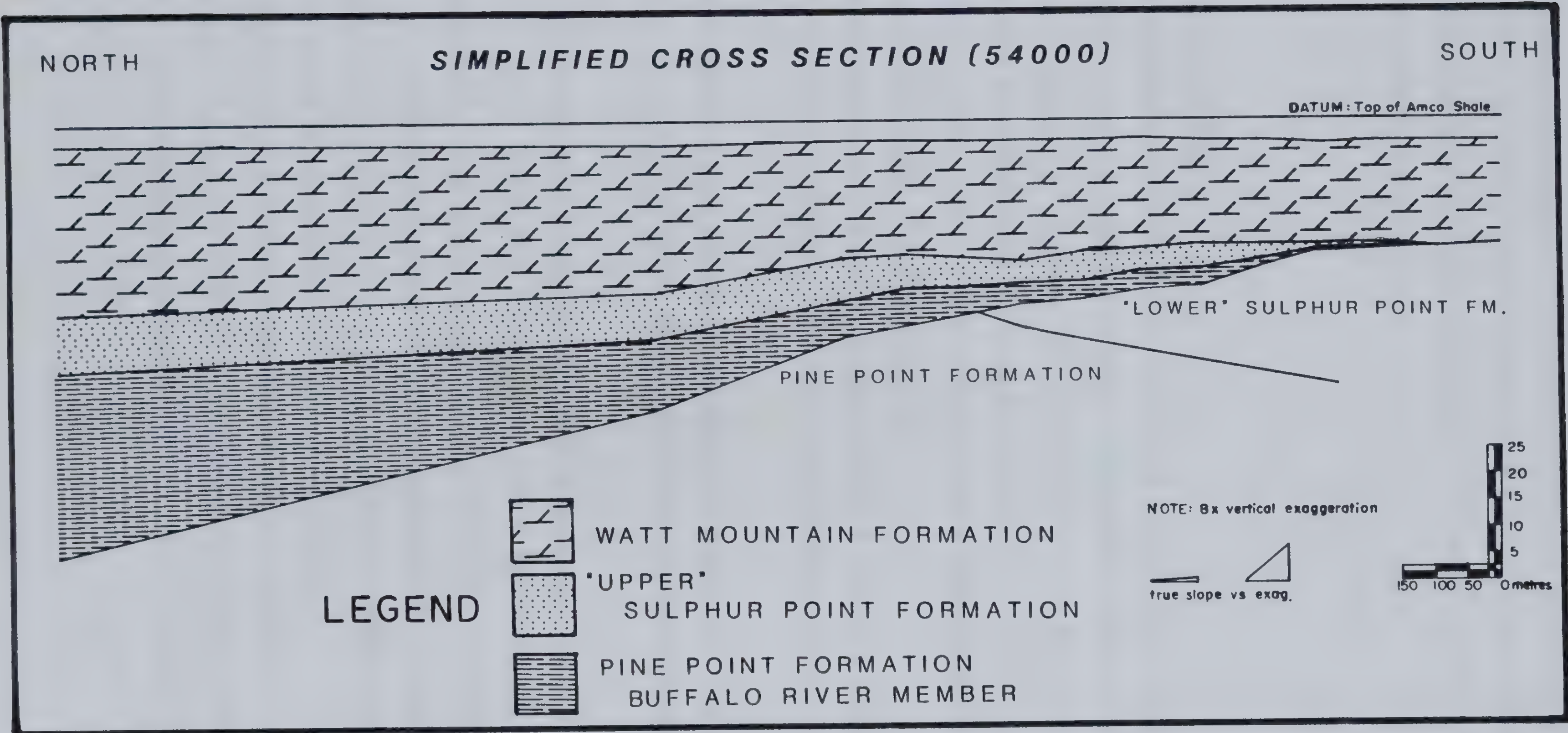

Figure 9. Simplified geologic cross section, showing relationship of overlying stratigraphy to northern edge of Pine Point Barrier Complex.

are presented in Appendix B. The relationship of the various lithofacies, one with the other, is schematically illustrated in Fig. 7. The three detailed cross sections (Figs. A, B and C, in back pocket) illustrate the more detailed stratigraphic relationships.

3.3.1 G-B LITHOFACIES.

G–B lithofacies is the basal unit of the Buffalo River Member, where it conformably overlies the marine B and F facies (Skall, 1975) of the Pine Point Formation. It reaches a maximum thickness of 6.5 m in the northernmost drillholes G–4 and 4640 (Fig. B, in back pocket). The unit thins toward the Pine Point Barrier Complex, and pinches out near the northern edge of the E (fore–reef) facies (Skall, 1975) development.

Both the upper and lower contacts of G–B lithofacies appear to be gradational and/or interfingering, over a vertical distance of 1.0 m or less.

G–B lthofacies is so named because it is essentially intermediate in appearance between B (marine) facies and G (Buffalo River Shale) facies (Skall, 1975).

G–B lithofacies is predominantly light grey–brown to brown–grey, dense, micritic limestone, which frequently shows a well developed bioturbated and burrowed texture. This characteristic "swirling" fabric is often highlighted by patchy iron sulphide replacement. This disturbed texture is often further accentuated by the alignment of both skeletal grains and clay particles. Such an effect is visible in both hand specimen and thin section.

Finely broken bioclastic material comprises at least 10% of the rock, by volume. Such fragments are predominantly brachiopod clasts, and vary in size from 0.1 – 1.0 mm (although larger fragments occur occasionally). Fine pelmatozoan debris can also be identified.

The matrix here comprises the bulk of the rock, and is extremely fine grained. It is estimated to contain, on average, approximately 15% argillaceous matter (Rasmussen, 1981), uniformly distributed within the micrite. It is this argillaceous content which lends the rock its characteristic "Buffalo River grey" colour. However, as stated previously, G-B lithofacies is intermediate in character between G and B facies, and this includes colour. The dark brown colour associated with B (marine) facies is primarily the result of hydrocarbon permeation, in the form of kerogen stringers (McQueen and Powell, 1983). This same effect, visible in thin sections of B (marine) facies, can also be seen in thin sections of G-B lithofacies, but is developed to a far lesser degree. It occurs primarily as a dark brown organic rim to the bioclastic material.

There would appear to be some sort of inverse relationship, here, between the amount of grey, argillaceous material, and hydrocarbon content. This would seem to suggest that the presence of clay minerals within the Buffalo River Member may have acted as an impermeable barrier to hydrocarbon migration. The relatively low argillaceous content of G-B lithofacies has allowed for minor infiltration.

Inasmuch as G-B lithofacies is a transitional unit, it naturally represents a spectrum of lithologies. These vary from an only slightly brownish grey, richly argillaceous limestone, in the vicinity of the overlying shales, to an organic rich, only slightly greyish brown, fossiliferous limestone, in the vicinity of B and F facies.

G-B lithofacies nearly always escapes dolomitization. However, in D. D. H. 5557 (Fig. B, in back pocket) recrystallization has occurred. The unit is still identifiable, on the basis of ghosted bioclastic material, visible in both hand specimen and thin section.

The high degree of bioturbation commonly encountered in this unit indicates that the bottom conditions were sufficiently oxygenated to allow burrowing organisms to flourish. On the other hand, conditions must have been sufficiently calm to allow for the settling of the fine clay particles. This influx

of terrigenous material into the basin may have been sufficient to inhibit carbonate production somewhat. In this way sedimentation rates must have been such that bioturbating organisms were able to keep apace with burial.

The onset of Buffalo River sedimentation, therefore, marks a change in environment, from the stagnant, reducing, conditions, evidenced by underlying F facies, to the better aerated conditions exemplified by G–B lithofacies. This change is certainly coincident with the onset of terrigenous input into the basin, and may relate to a regressive event. However, there is little, or no, evidence to suggest that any *drastic* change in water depth was involved. A more likely candidate would seem to be some sort of change in water current patterns, within the basin.

3.3.2 G5 LITHOFACIES.

G5 lithofacies is the basal unit of the Buffalo River Member, where it overlies the fore-reef facies of the Pine Point Formation (E facies, Skall, 1975), the reef facies of the "Lower" Sulphur Point Formation (D2 facies, Skall, 1975), and the BRS (biohermal) facies of the Pine Point Formation (Pine Point Mines Ltd. usage.)

The unit averages approximately 1.5 m in thickness, primarily where it overlies E facies, and thins southward, as it approaches its depositional and/or erosional edge, overlying D2 facies. Both the upper and lower contacts of G5 lithofacies are sharp, and well defined. The lower contact with the various facies of the Pine Point Barrier Complex is usually marked by a strong crystallinity change. The underlying facies comprising the Barrier Complex have nearly always undergone an intense recrystallization, referred to as "Presqu'ilization". This has resulted in the growth of dolomite crystals, in excess of 1.0 mm, and up to 7.0 mm in diameter (J. Lantos, unpub. report, 1981b). This diagenetic effect does not extend upward into the G5 lithofacies, but rather stops sharply at the contact.

G5 lithofacies is overlain by a variety of lithologies. To the south, where G5 comprises the entire Buffalo River Member, it is overlain by the most reefal development of the "Upper" Sulphur Point Formation. Farther north, G5 lithofacies is overlain by either the G1 (shale) lithofacies, or the G2 (nodular) lithofacies of the Buffalo River Member. In all cases, the contrast between G5 and the overlying lithologies is sufficient to render the contact sharp and distinctive.

G5 lithofacies is primarily a brownish grey, fine to medium crystalline, fairly dense, massive calcarenite. It is rarely preserved as limestone, but is nearly always dolomitized. It can, nevertheless, generally be recognized as a finely bioclastic interval. Well sorted, somewhat rounded, grain-supported, bioclastic and pelloidal debris, averaging 0.5 mm in diameter, can be recognized, both in thin section, and in less extensively dolomitized sections. The peloids are particularly striking, in both appearance and abundance (up to 20% by volume). They are subrounded, but somewhat irregular in shape, average no more than 0.1 mm in diameter, and, as with most peloids, are of doubtful origin. In common with the coarser bioclastic material, these grains are frequently coated by a medium grey, argillaceous material. The bioclastic debris is, on the whole, difficult to identify, but appears to be primarily derived from brachiopods, stromatoporoids, and corals.

For the most part, the unit has been extensively recrystallized to a fine rhombic dolomite, with crystals averaging 0.05 – 0.1 mm in size. These distinctive rhombs are frequently surrounded by a coating of grey argillaceous matter. Where such recrystallization has occurred, bioclastic material is recognizable in terms of ghosted outlines, differentiated by coarser, and more tightly interlocking dolomite crystals.

Sedimentary structures, which may, or may not, have been present originally, are no doubt largely destroyed by dolomitization. However, vague graded bedding, and high angle cross-bedding have been tentatively identified by Rasmussen (1981). Certainly, in D. D. H. 4334, a very coarsely bioclastic interval

can be identified, at the base of the G5 interval. This grades upward into finer bioclastic material, more typical of G5 lithofacies.

The overall grey colour of this unit is attributed to the fine clay particles (estimated to contain no more than 3% by weight, Rasmussen, 1981) which uniformly rim both bioclasts and dolomite rhombs. This argillaceous material is also, occasionally, concentrated along discrete partings, sub-parallel to bedding. This gives the unit, in part, a faint wispy lamination.

Toward the top of the interval, G5 lithofacies may occasionally develop a well laminated/finely bedded character. 1.0 – 2.0 cm thick beds of relatively clean calcarenite are separated by dark grey, argillaceous laminae, planar and uniform in nature. This is distinguishable from the underlying "normal" G5 only on the basis of this more regular bedding style.

The fairly fine, well sorted, bioclastic nature of this unit is suggestive of deposition within an agitated environment. The similarity of the bioclastic debris to that comprising E (fore-reef) facies suggests that G5 was largely derived from reworking of both E facies and the various other Barrier Complex facies. G5 is presumed to have been deposited toward the edge of the southward transgressing Buffalo River sea, at a time when much of the Barrier Complex was sub-aerially exposed (or very recently inundated). As such, it is believed to be a diachronous unit, prograding southward onto the barrier, in concert with the transgression. This is strongly suggested by both the geometry of the unit, and its tendency to evidence waning upward energy conditions.

3.3.3 G1 LITHOFACIES.

G1 lithofacies is the predominant, and characteristic, unit within the Buffalo River Member. It forms a northward thickening wedge, and overlies both G-B lithofacies, in part G5 lithofacies, and is found resting (rarely) directly on the Barrier Complex (Fig. 7). It frequently hosts two interbeds of distinctive G2

lithofacies: however, at its maximum (and most northerly) measured thickness (approximately 48.0 m) in Cominco Test Hole G-4, such interbeds are not developed.

This dominant G1 lithofacies development is overlain by the G B Marker Bed. Immediately overlying this G B Marker Bed is another, very narrow, wedge of G1 lithofacies. It reaches a maximum thickness of 3.5 m in D. D. H. G-4, and forms the uppermost unit of the Buffalo River Member, over most of its development.

G1 lithofacies consists primarily of a greenish grey, fissile, calcareous shale. Such bedding plane fissility is greatly enhanced by weathering, such that it is not always strongly demonstrated in fresh core.

Insoluble residue content averages 75% by weight (Rasmussen, 1981). It consists primarily of grey clay, but also includes rare, fine (silt sized), frosted grains of rose quartz. The clay:carbonate ratio increases away from the Barrier Complex, from 2:1 near the G1 pinchout, to 4:1 in D. D. H. G-4. This variation in clay content is reflected in the fissility of the unit, and in this way, local variations in clay content can be recognized. In this respect, the shale generally shows an increased competency (and thereby increased carbonate content?), in proximity to purer carbonate intervals, such as the G B Marker Bed, or the overlying "Upper" Sulphur Point Formation.

G1 lithofacies shows a marked paucity of macro-fauna, with the exception of rare brachiopod shells. Pyrite, in euhedral cubes, or subhedral aggregates, occurs as fine disseminations throughout G1 lithofacies, and is considered characteristic. Primarily limy, the shale is dolomitized locally, particularly in the vicinity of the Barrier Complex itself, and especially in conjunction with karsted and brecciated zones. The thin G1 wedge, immediately overlying the G B Marker Bed, is nearly always dolomitized.

G1 shales may be reworked and redeposited within karst horizons. Upon relithification, this material is virtually identical to undisturbed shales, and is identified, as such, more by context than character.

The presence of greater than 50% clay, within this interval, reflects the influx of terrigenous material into the basin, at the time of its deposition. Bottom conditions were apparently inhospitable to any kind of benthonic fauna. This is reflected in the absence of either macro-fauna, or sign of bioturbation. This, in turn, might be considered a sign of rapid sedimentation rates, in spite of inhibited carbonate production.

Deposition of such fine clay particles would presumably require calm bottom conditions, indicative of water depths at least below wave base. Rasmussen (1981) has suggested that the absence of dark brown organic matter, within the G1 shales, is indicative of oxidizing conditions, and that iron sulphides were deposited under later, post-depositional, reducing conditions. There is, however, another possibility, which should be considered: that the dark brown organic material, ubiquitous in both the underlying and overlying "clean" carbonates is, in itself, secondary in origin, and is the result of hydrocarbon migration. As such, it cannot be used as an indicator of original depositional conditions. In thin section, a direct inverse relationship between grey clay and hydrocarbon content can be identified, suggesting that the argillaceous material acted as either a barrier, or inhibitor, to such migration.

In any event, the G1 shales represent the dominant basin filling sediment here. They represent a period of marked terrigenous input into a previously "clean", carbonate, basin. This appears to be the result of a marine transgression, following the significant regression which had ended "Lower" Sulphur Point time.

3.3.4 G2 LITHOFACIES.

G2 lithofacies occurs primarily as two distinct interbeds, within G1 lithofacies. Reaching a maximum thickness of approximately 3.5 m, they pinch out toward the north, such that neither can be traced into D. D. H. G-4. They also pinch out toward the south, in the vicinity of the G1 pinchout.

The lower of the two is of the most limited lateral extent, although they both extend only about as far south as the most northerly G5 development, at which point they apparently coalesce. The upper and lower contacts of both these interbeds is generally transitional over several cm.

G2 lithofacies is a nodular textured, argillaceous limestone, and is considerably more competent than the surrounding shales. This is a reflection of the marked drop in argillaceous content within this unit (10–20% by weight, Rasmussen, 1981). Nonetheless, argillaceous content continues to increase toward the north, paralleling the same trend identified in the shales.

The nodules are variable in size, ranging up to 5.0 cm in thickness, and are generally elongate parallel to bedding. Generally appearing as discrete forms, they can occasionally be seen to coalesce.

Compositionally, both "matrix" and nodules are very similar. However, clay particles are greatly more concentrated within the matrix areas, both disseminated and in wisps. Boundaries between the nodules and the matrix are quite diffuse, and are much more distinct macroscopically than microscopically. Boundaries are only well defined when enhanced by later pressure solution activity.

The relative abundance of nodules may vary greatly from place to place. Yet even when completely absent, the interval is still identifiable on the basis of the decreased clay:carbonate ratio (with associated increase in competency), and the slightly browner colouration.

Macrofossils are more abundant here than within G1 lithofacies, but are only of local importance. Brachiopods, apparently in place, occur sporadically, and even thamnoporid coral fragments are known. The latter, however, are presumed to be exotic in origin.

G2 lithofacies apparently reflects either a) a reduction in terrigenous supply to the Mackenzie basin (or at least to its southernmost extension), or b) increasingly agitated bottom conditions, such that fine clays could not as readily

settle out of suspension. The presence of a more abundant fauna might be interpreted as supporting the latter conclusion. On the other hand, a decrease in terrigenous input, might, in itself, decrease turbidity, and thereby provide more hospitable living conditions.

A diagenetic origin for this texture cannot be entirely overlooked. Nevertheless, G 2 lithofacies shows very little evidence of solution activity. The "common stylolites" or "microstylolite swarms" required within the pressure solution model put forward by Wanless (1979) are not present. The lack of any distinct boundaries to these nodules, or associated evidence of boring and encrusting organisms, would also seem to negate any hard-ground interpretation.

These nodules do appear, to the writer, to represent early submarine lithification or cementation of the nodules themselves. The resulting plastic sediment then underwent compaction, such that wisps and laminae within the matrix were caused to splay about the more competent nodules. It is suggested that this nodular textured limestone is an ancient analogue to the submarine hard grounds, or hard layers, described from the Persian Gulf (Taylor and Illing, 1969). Such an interpretation requires marine conditions, but with sedimentation rates slow enough to maintain the required position within the sediment/water interface.

3.3.5 G B MARKER BED.

The G B Marker Bed occurs as a thin, uniform and laterally continuous unit, toward the top of the Buffalo River Member. It is both underlain and overlain by G1 (shale) lithofacies, and in thickness averages a consistent 0.5 m. It frequently marks the diagenetic boundary between the upper G1 shales (nearly always dolomitized), and the lower G1 shale wedge (ordinarily limy). The Marker Bed, in itself, is nearly always dolomitized. Farther north, away from the Barrier Complex, this general relationship is no longer observed.

The G B Marker Bed is a medium to dark brown, fine grained carbonate. Wispily argillaceous in part, it contains a marked organic component, especially concentrated along wispy partings. The grey clay fraction, characteristic of all other Buffalo River lithofacies, is entirely absent.

The unit is normally recognised as being devoid of macrofossils. Nevertheless, farther to the north a fairly diverse fauna can be identified, including thamnoporid corals, pancake/tabular stromatoporoids, and occasional thin-shelled brachiopods.

The lower contact of the G B Marker Bed is usually sharp and distinct. The upper contact is similarly distinct, but is characterized by the development (over a vertical distance of some 1-5 cm) of small, grey, concretionary structures. These vary in thickness from 1.0 mm to 1.5 cm, and are always elongate parallel to bedding. In cross section they show a concentric lamination, occasionally nucleating about some small bioclastic fragment. Such concretions increase in abundance toward the top of the unit, ultimately coalescing to form the overlying G1 lithofacies. Hydrocarbon enhanced wisps and laminae splay about both these "nodules" and rare fossil fragments, suggesting post depostional compaction.

The deposition of the G B Marker Bed represents a sudden and marked change in depositional conditions within the basin. For a distinct period of time, the feature of Buffalo River Sedimentation, specifically the grey clay fraction, was completely withdrawn, such that "normal" marine carbonate deposition was possible.

The paucity of fauna suggests that conditions remained somewhat inhospitable (at least in the vicinity of the Barrier Complex). This might, perhaps, reflect the somewhat restricting effect of biohermal activity? seaward of the Barrier Complex.

A shallow, calm, fairly stagnant environment is thereby suggested. The abundant concretionary structures at the top of the unit are considered characteristic of an environment becoming transitional into shale deposition, once

more.

3.4 THE "UPPER" SULPHUR POINT FORMATION.

Introduction.

The "Upper" Sulphur Point Formation is known primarily from the subsurface of the Pine Point Mines Ltd. property. It is also known from outcrop on the south shore of Great Slave Lake, at Sulphur Point, and has been reported from the Windy Point area (Norris, 1962).

From its southern depositional and/or erosional edge, paralleling the N65 E strike of the Barrier Complex, the unit forms a very gradually thickening wedge (Fig. 9). It reaches a maximum thickness of 18.9 m in Cominco Test Hole G-4, approximately 9 km to the north (Fig. B, in back pocket). As a result of the very gentle regional dip to the west, the "Upper" Sulphur Point Formation is truncated to the east by erosion, and is found at ever increasing depths toward the west. In keeping with its relatively thin development, the subcrop pattern (delineated by extensive drilling) is necessarily limited.

The various facies of the "Upper" Sulphur Point Formation rest directly on either G5 lithofacies, or G1 lithofacies, of the Buffalo River Member. Where B Biostromal facies forms the basal unit of the "Upper" Sulphur Point Formation, the basal contact (primarily with G1 lithofacies) is at all times sharp and distinct. Where the Reefal facies forms the basal unit of the "Upper" Sulphur Point Formation, it is normally underlain by G5 lithofacies. Once again, the contact is generally distinct, but may develop a more gradational appearance over a few cm. All basal contacts, with underlying Buffalo River lithologies, are believed to be conformable.

The "Upper" Sulphur Point Formation is, at all times, overlain by the Lower Shale member of the Watt Mountain Formation. Where the Reefal facies forms the uppermost member of the "Upper" Sulphur Point Formation, the contact is believed to be unconformable. Where the restricted facies forms the

uppermost unit, the contact with the overlying Watt Mountain Formation is somewhat gradational, and believed to be conformable.

"Upper" Sulphur Point Formation Lithologies.

The "Upper" Sulphur Point Formation is divisible into three lithofacies. This subdivision is based on lithologic features clearly discernible in hand specimen, on the basis of colour, texture, and faunal content. It is the result of the investigation of numerous drill intersections, beyond those presented as documentation for this thesis.

Photographs, representative of these three lithofacies in hand specimen, are presented in Appendix C, Plate 2. Selected thin section descriptions are presented in Appendix B. The relationship of the various lithofacies, one with the other, and with the underlying and overlying units, is illustrated in the detailed cross sections (Figs. A, B and C, in back pocket).

3.4.1 THE REEFAL FACIES.

The Reefal facies of the "Upper" Sulphur Point Formation is a massively fossiliferous carbonate. Frame building organisms predominate. Thamnoporid corals are abundant, and are considered characteristic. Similarly, stromatoporoids, specifically massive, encrusting, and tabular forms, are common, along with thick-shelled brachiopods.

Frequently, there is little micrite or very fine matrix material. When present, it consists of fine to coarsely bioclastic material, apparently entirely locally derived. The original sediment was clean and well winnowed, such that all fine material has been removed.

In part, the unit is only poorly consolidated. This is especially true toward the south (at the unit's thinnest development) and toward the top of the unit. Here, spaces between organic remains are frequently filled with green clay (derived from the overlying Watt Mountain Formation) or a tarry black bitumen.

The green clay is especially abundant in the uppermost metre or so, where the interval has a distinctive rubbly appearance. The bitumen is common throughout the interval: where loosely indurated, it occurs in discrete, sticky masses, literally gluing the fossils together; where the Reefal facies is better indurated, the bitumen occurs as fine disseminations, imparting a characteristic purplish grey hue to the rock. Such denser, more tightly consolidated, sections are apparently the result of post-depositional cementation by sparry calcite. In all cases, however, it would seem that initial organic binding, penecontemporaneous with sedimentation, was of primary importance.

The interval has nearly always suffered some degree of dolomitization. However, it is entirely different in nature to that affecting the "Lower" Sulphur Point Formation, for it is far less destructive. Whilst some of the finer detail may have been lost, dolomite crystals are relatively small, and the replacement process quite delicate.

The diverse fauna, which dominates this interval, suggests deposition occurred in an area where environmental conditions (temperature, salinity etc.) were hospitable to such life forms. The presence of robust, frame-building organisms might, in turn, indicate high energy conditions. Furthermore, shallow water conditions, well within the photic zone, are indicated. The terrigenous fraction, which completely dominated Buffalo River sedimentation, is completely absent.

All of the above, together with the linearity of the facies development (paralleling the strike of the earlier barrier), and relative stratigraphic position, suggests deposition in a fringing reef environment, fringing the emergent Barrier Complex.

The exact southward extent of its development, and the possibility of contemporaneous back-reef sedimentation (within more of a barrier reef situation) must, forever, remain a mystery. The facies has been truncated, to some degree, by erosion, occurring some time soon after its deposition.

3.4.2 THE B BIOSTROMAL FACIES.

The B Biostromal facies of the "Upper" Sulphur Point Formation is remarkably uniform in thickness, averaging approximately 4.5 m.

It is found, at all times, immediately overlying the G1 lithofacies of the Buffalo River Member. This basal contact is sharp, and extremely distinctive. B Biostromal facies is generally overlain by the Restricted facies of the "Upper" Sulphur Point Formation, in a manner that is somewhat transitional. For the most part, the contact is gradational, over several cm. Consequently, the precise placing of the upper contact is often based on a coincident diagenetic boundary, for, whereas the B Biostromal facies is nearly always dolomitized, the Restricted facies is nearly always preserved as limestone.

Toward the south, however, in the vicinity of the Reefal facies development, this upper contact may be considerably sharper. It is often marked by a 3-6 cm band of brown clay. On rare occasions (i.e. D. D. H. 4317) subangular fragments, apparently derived from erosion of the adjacent Reef facies, can be identified within such clay seams.

The B Biostromal facies of the "Upper" Sulphur Point Formation is a fairly uniform, dense, somewhat wispily argillaceous dolomite. It is strikingly similar to the G B Marker Bed of the Buffalo River Member (which no doubt represents an earlier period of B Biostromal-like deposition).

The interval is generally characterized by an upper portion more or less devoid of macrofauna, and a lower half which contains abundant, matrix supported, thamnoporid corals, and lesser stromatoporoids. The sharp colour contrast, between the pinkish beige corals, and the medium to dark brown matrix, lends the rock a very striking appearance.

Dolomitization has resulted in the growth of extremely fine (0.05 mm) dolomite rhombs, within what was, apparently, originally some kind of fine carbonate mud. Irregular, faint, argillaceous wisps may have been occasionally developed within this matrix. Such partings have, however, been considerably enhanced by hydrocarbon staining. Such organic material is abundant, finely

permeating all B Biostromal matrix material. It is observed to rim the fine dolomite crystals, separating them, one from the other.

A leaching of the coarser fossil fragments is commonly seen in the lower half of this interval, resulting in the development of a characteristic fossil moldic vugginess. Such vugs are often filled by a thick, tarry, black bitumen, similar to that found within the Reefal facies.

B Biostromal facies is believed to have been deposited contemporaneously with the Reefal facies, and as such, to represent a seaward, shallow carbonate platform equivalent.

The wispy nature of the laminations, and the presence of a stromatoporoid/coral fauna (apparently in situ) suggests moderately agitated, fairly shallow water conditions. The onset of B Biostromal deposition marks the sudden withdrawal, from the basin, of the terrigenous fraction ubiquitous during Buffalo River sedimentation. This, alone, may well have been sufficient to render conditions more hospitable toward life. No great change in water depth is envisioned, except for a very gradual shallowing.

The paucity of fauna in the upper half of the interval suggests that conditions may have become progressively less hospitable. Considering the stratigraphic position of the interval, this could be interpreted as being the result of shallowing conditions, with associated elevated salinities.

3.4.3 THE RESTRICTED FACIES.

The Restricted facies of the "Upper" Sulphur Point Formation forms a northward thickening wedge of sediment overlying, primarily, the B Biostromal facies. From a zero thickness, more or less coincident with the northern edge of the Reefal facies, the interval reaches a maximum thickness of 8.7 m in Cominco Test Hole G-4.

Whilst the interval is clearly distinguishable from both overlying, and underlying units, contacts (particularly basal contacts) are often gradational over a few cm.

It should be mentioned, at this point, that this interval has traditionally been included in the overlying Watt Mountain Formation by Pine Point Mines Ltd. geologists. With regard to its relative stratigraphic position and character, the interval was named the "Basal Marine member" (J. Lantos, unpubl. report, 1981a). However, inasmuch as Norris included the interval in his type section of the Sulphur Point Formation (in D. D. H. G−4), and insofar as there is a greater lithologic break at the top of the interval, than at the base, it is here included in the "Upper" Sulphur Point Formation.

The Restricted facies of the "Upper" Sulphur Point Formation is characterized by its tendency to become lighter in colour toward the top. From a light, distinctly pinkish brown colour, it darkens, with depth, to a medium brown colour, virtually identical to the underlying B Biostromal facies.

The interval is further characterized by a distinctive textural feature, unique to the facies. This texture is easily identifiable, either when dolomitized, or preserved as limestone. In the former case, the texture is frequently described as "blebby", with small, vermiform, calcite filled cavities, abundantly distributed throughout the fine grained dolomite. When the interval is preserved as limestone, as is more often the case, similar, elongate features are observed. In this latter case, such cavities are generally partially filled with a soft green clay, derived from the overlying Watt Mountain Formation. These elongate cavities, or blebs, are interpreted as representing burrowing, or boring structures.

The rock, itself, is predominantly a clean, fine micrite or carbonate mud. Largely devoid of macrofauna, it contains a restricted population of ostracods and foraminiferids, especially more abundant toward the base.

The interval is largely homogeneous in appearance, but develops a tendency to become more laminated toward the top.

The Restricted facies of the "Upper" Sulphur Point Formation is interpreted as representing an upward shallowing sequence. It is transitional, between the open marine carbonates evidenced by the B Biostromal facies, and the shallow, restricted conditions ascribed to the lowermost members of the Watt Mountain.

The nature of the sediment, and the fauna, indicates deposition in a somewhat restricted, shallow marine environment, most likely sub-tidal in nature. The fine grained make-up of the sediment indicates quiet conditions, either below wave base, or otherwise sheltered,or protected, from strong wave action. Initially the former seems the more likely. However, as time progressed, water depths no doubt decreased, resulting in a more laminated texture being developed. The sediment would, at all times, have been sheltered from strong wave action, simply by the extensive development of shallow water conditions at this time.

The ubiquitous bored or burrowed character, suggests that conditions were, at some point at least, hospitable to the responsible organisms. The nature of the features themselves suggests development post-dating consolidation to, at least, a plastic state. This resulted in a riddling of the rock by these burrow networks. Technically, then, as such a secondary feature, they might be considered more representative of conditions at the end of "Upper" Sulphur Point time, at the time of the Watt Mountain transgression.

3.5 THE WATT MOUNTAIN FORMATION.

Introduction.

The Watt Mountain Formation is known throughout the subsurface of both northern Alberta, and the southern Northwest Territories. It is developed extensively on the Pine Point Mines Ltd. property. It occurs, not only to the north of the Barrier Complex (overlying the "Upper" Sulphur Point Formation) but also extends far to the south, unconformably overlying both the "Lower" Sulphur

Point Formation, and farther to the south, the Muskeg Formation. It is overlain by the Slave Point Formation, specifically, in the Pine Point region, by the Amco Member.

The Watt Mountain Formation averages less than 10.0 m in thickness where it disconformably overlies the central portion of the Barrier Complex, and thickens northward, reaching a maximum thickness of 32.5 m in D. D. H. 4323 (Fig. A, in back pocket).

In keeping with the overall gentle regional dip toward the west, the Watt Mountain Formation has largely been removed, by erosion, from the eastern half of the Pine Point Mines Ltd. property. West of this erosional edge, the Watt Mountain Formation is intersected in all diamond drill holes, due to its almost layer-cake like continuity. Even farther west, the formation is overlain by ever increasing thicknesses of Slave Point Formation.

Both upper and lower contacts are, at all times, sharp and distinctive. The basal contact is defined at the first occurrence of the characteristic blue-green clay. The uppermost contact is defined at the first occurrence of the wispy, stromatoporoidal and oncolitic limestone, known as M3 facies of the Amco Member of the Slave Point Formation.

Watt Mountain Formation Lithologies.

The Watt Mountain Formation is divisible into seven lithofacies. This subdivision is based on lithologic features clearly discernible in hand specimen, primarily on the basis of colour and texture. It is the result of the study of several hundred drill intersections throughout the Pine Point Mines Ltd. property (J. Lantos, unpubl. report, 1981a), and is further documented by the three cross sections presented in this thesis. It is considerably different from that subdivision proposed by Wiley, in his unpublished M. Sc. thesis (1970), and is the breakdown currently accepted by Pine Point Mines Ltd. geologists.

Photographs, representative of the various lithofacies, are presented in Appendix C, Plate 3, whilst representative thin section descriptions can be found in Appendix B.

The relationship of the various lithofacies, one with the other, is illustrated in Fig. 10. This schematic cross section is based on a fence of holes drilled approximately 6000 m west of 54000 cross section (Fig. A, in back pocket). It, too, is drawn perpendicular to the strike of the Barrier Complex, and covers an equivalent north-south interval.

The relative stratigraphic position of the Watt Mountain Formation, specifically as developed north of, and adjacent to, the Pine Point Barrier Complex, is illustrated in Figs. A, B and C (in back pocket).

3.5.1 THE LOWER SHALE MEMBER.

The Lower Shale member of the Watt Mountain Formation forms the basal member of the formation, throughout the Pine Point Mines Ltd. property. The Lower Shale member overlies both the various facies of the "Lower" Sulphur Point Formation, and the Reefal and Restricted facies of the "Upper" Sulphur Point Formation. It is overlain, throughout the area, by the Silty Dolomite member of the Watt Mountain Formation.

Where the member overlies the Restricted facies, sedimentation is believed to have been continuous, and the contact conformable. Farther south, where the Lower Shale member overlies the Reefal facies of the "Upper" Sulphur Point Formation, and the barrier facies of the "Lower" Sulphur Point Formation, the basal contact is believed to be unconformable.

Of all the units within the Watt Mountain Formation, it is primarily this Lower Shale member which effects the northward thickening nature of the formation, for by the end of its deposition the filling of the "Buffalo River Basin" had essentially been achieved. The member, therefore, shows its thickest development north of the Barrier Complex, where it conformably overlies the Restricted facies of the "Upper" Sulphur Point Formation. It reaches a maximum thickness of 9.8 m, in D. D. H. 4323 (Fig. A, in back pocket).

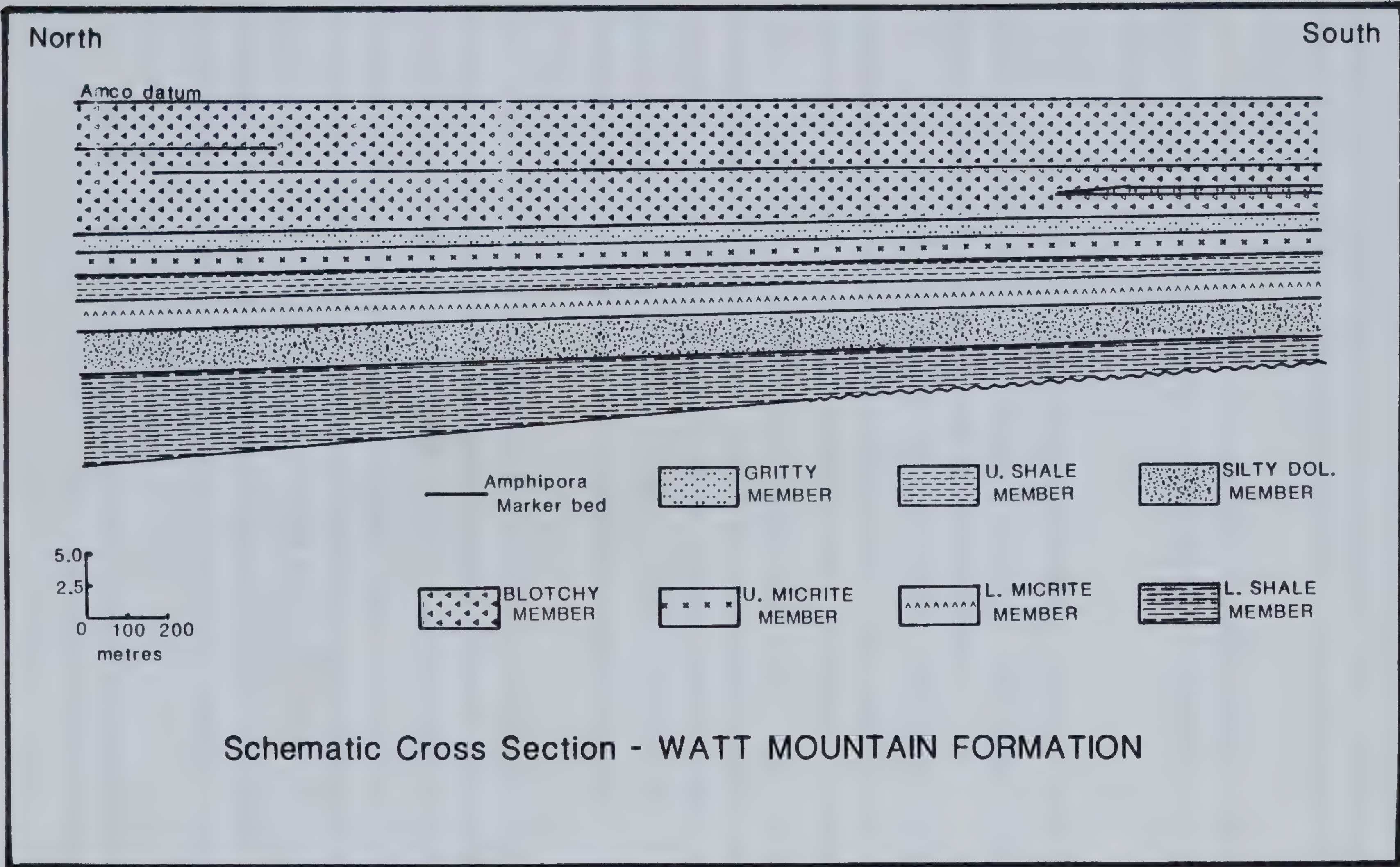

Figure 10. Schematic cross section, showing Watt Mountain Formation member relationships.

To the south the interval thins, specifically where it unconformably overlies both the Reefal facies of the "Upper" Sulphur Point Formation, and the Barrier Complex itself, to a minimum of 4.6 m in D. D. H. 4310 (Fig. A, in back pocket).

Variation in thickness of the Lower Shale member, where it overlies the previously exposed Barrier Complex, is interpreted as a reflection of original palaeo-relief on the Complex itself.

It is this interval, above all, which has come to exemplify the Watt Mountain Formation. This is primarily due to its bluish green colour, which is generally considered synonymous with the Watt Mountain.

The interval is moderately competent, extremely fine grained, and has a characteristic dull, earthy (or chalky) texture. Soft, fissile shales, per se, occur only rarely. As such, the interval is perhaps better described as a sequence of marls, or argillaceous limestones and dolomites, together with some highly intraclastic beds of cleaner micrite. Toward the north, earthy cryptocrystalline dolomites are developed, light coffee brown in colour, and associated with gypsum and anhydrite. In this way, the interval is frequently described as being heterogeneous on a small scale, yet nevertheless forming an overall homogeneous package.

Whilst the blue-green ("Watt Mountain green") colour predominates, interbeds of clean, chalky textured, cream coloured carbonate occur commonly throughout. Such interbeds are generally fairly thin and discontinuous, and frequently lend the rock a marbled, or pseudo-nodular texture. This texture is no doubt enhanced by post-depositional compaction, causing green clay wisps to splay about such nodules or lumps. The texture is apparently the result of variations in the availability of argillaceous material, and, to some extent, syn-sedimentary lithification of the nodules. There is no evidence to suggest that any bioturbation has occurred here.

For the most part, the interval has been preserved as dolomite. However, to the north, specifically where the interval conformably overlies the Restricted

facies of the "Upper" Sulphur Point Formation, the lower half of this Lower Shale member is frequently preserved as limestone. Whether dolomite or limestone, the unit is identical in appearance, and is at all times extremely fine grained.

Gypsum and/or anhydrite is occasionally developed within this interval, especially toward the north. Such evaporites occur as small rounded nodules within the marls, producing a distinctive "chicken-wire" texture. Evaporites are most commonly developed toward the top of the interval, and frequently straddle the contact with the overlying Silty Dolomite member.

A fine intrastratal collapse texture is frequently observed within this unit, resulting from the dissolution of such evaporitic intervals.

The interval is largely devoid of biota, with the exception of relatively rare charophyte oogonia.

It is this interval which represents the initial marine transgression over the Barrier Complex.

Green clays are commonly associated with unconformity deposits within carbonate regimes, and yet their origin has long been debated. In view of this common association, the clays are generally believed to have been derived from extensive dissolution of the underlying carbonates. However, in consideration of the fact that green shale deposition continued long after burial of the Barrier Complex, such a source seems unlikely. According to Wiley (1970), X-Ray Diffractometer results indicate the clays are primarily composed of the mineral illite, but he offers no suggetion as to origin.

In any event, the interval is believed to have been deposited in shallow, restricted waters, of extensive lateral extent. The intraclastic texture, occasionally developed here, is believed to represent sediment disturbed by either exposure to dessication or storm/wave influences.

The transition from limestone to dolomite toward the top of the member, with associated evaporite development, is indicative of increasingly restricted conditions. The fine grained, earthy, cryptocrystalline texture of the dolomite

here is suggestive of a very early dolomite, virtually contemporaneous with sedimentation.

The Lower Shale member, then, is interpretated as a shallowly transgressive interval, initially deposited only to the north of the Barrier Complex, but quickly spreading southward. Conditions were at all times shallow, and restricted, becoming more so toward the end of "Lower Shale time".

3.5.2 THE SILTY DOLOMITE MEMBER.

The Lower Shale member is, at all times, overlain by the Silty Dolomite member, which is in turn, at all times, overlain by the Lower Micrite member. Both the upper and lower contacts of the Silty Dolomite member are usually sharp and well defined (except where obscured by the development of evaporites).

The interval averages approximately 3.0 m in thickness, increasing somewhat toward the north. Core recovery of this interval is often very poor, and this, in itself, is considered characteristic.

The Silty Dolomite member is a distinctive, light creamy brown in colour, and is, at all times, preserved as dolomite. Generally homogeneous, it occasionally exhibits a fine laminated appearance.

A fine, "silty" texture predominates throughout this interval, as does an extremely light, porous texture. This results in a fairly friable nature (and thereby poor core recovery) which, together with porosity, is considered extremely characteristic.

Nodular textured evaporites occur occasionally, especially toward the base of the unit. Evaporites also occur in thin, interlaminated, bands, clearly displacive in nature, and as lath or blade like crystals (or pseudomorphs thereof). As with the underlying shales, evaporite dissolution often results in the development of a classic intrastratal collapse texture.

No fauna has ever been recorded from this interval.

The Silty Dolomite member is believed to represent extremely shallow, possibly supratidal deposition, under high evaporative conditions, resulting in the development of a very early dolomite, within which gypsum needles were able to grow. The nodular gypsum, which is occasionally found here, and in the underlying shales, may well have also been developed at this time, for it has a texture, at least in part, reminiscent of a replacement origin.

The Silty Dolomite member, then, represents extremely shallow, restricted, possibly even Sabkha-like, conditions. Such an environment would be extremely inhospitable to most life forms.

3.5.3 THE LOWER MICRITE MEMBER.

The Lower Micrite member immediately overlies the Silty Dolomite member, and is overlain by the Upper Shale member. It averages approximately 3.0 m in thickness, and is uniformly developed throughout the area. Both its upper and lower contacts are sharp and well defined.

The Lower Micrite member is a fairly dense, very light creamy brown, micritic limestone. It generally shows a very uniform, homogeneous texture, but occasionally exhibits a faint, slightly darker brown, mottled texture, or faint bedding laminae.

Fine, lath-like gypsum crystals are sporadically developed here. However, they are rarely preserved, and are usually leached, to give a characteristic, cellular vugginess. Stylolites are also commonly developed. For the most part the interval is quite competent. However, where ubiquitous small vugs become very abundant, the member develops a tendency toward a crude bedding-plane fissility.

The interval is devoid of both mega and microfauna.

The interval is believed to have been deposited in quiet, shallow waters, most probably subtidal and fairly restricted in nature.

3.5.4 THE UPPER SHALE MEMBER.

The Upper Shale member generally averages less than 3.0 m in thickness. It immediately overlies the Lower Micrite member, and is in turn overlain by the Upper Micrite member. It is uniformly developed throughout the interval.

Both upper and lower contacts are usually distinct, but where they are somewhat more gradational, they are defined at the first and last occurrence of green clay.

The Upper Shale member is another heterogeneous sequence of shales and dull earthy marls. However, unlike the Lower Shale member, true, soft, fissile shales do occur here; indeed, they are characteristic. The central third of the interval is dominated by dark, blue-green, limy shales, 1.0 -1.5 m in thickness, which in turn, often sandwich a thin (up to 10 cm) interbed of dark brown shale. All of this shaly material is extremely soft, fissile, and, often, almost clay-like in texture. The blue-green colour here is much darker than the milkier blue-green, observed in the Lower Shale member. Nevertheless, marls similar to those found within the Lower Shale member, and of a similar milky blue-green colour, can be found sandwiching this central, shaly portion. These argillaceous limestones, dull and earthy in texture, form competent beds, up to 1.0 m in thickness. Out of context, they would be difficult to distinguish from portions of the Lower Shale member.

As with the Lower Shale, rare charophyte oogonia are sporadically preserved, but generally the interval is devoid of biota.

The interval is believed to represent continued shallow water deposition, but at a time of marked terrigenous input. The origin of this clay is not known, and its geologic significance not fully understood.

3.5.5 THE UPPER MICRITE MEMBER.

The Upper Micrite member overlies the Upper Shale member, and is, in turn, overlain by the Gritty member. It averages 3.0 m in thickness, and is uniformly developed throughout the study area. Both upper and lower contacts are generally well defined, and easily identifiable.

The Upper Micrite is a light creamy white, micritic limestone, and is extremely homogeneous in nature. It is very similar to the Lower Micrite member (previously described), and at times is indistinguishable from that unit. Like the Lower Micrite, it is strongly stylolitic in nature, and generally shows an extremely well developed cellular vugginess. Gypsum laths are rarely preserved, and the fine vugs are again interpreted as leached molds of such crystals.

The interval is devoid of fauna.

The interval is presumed to have been deposited under the same shallow, restricted conditions ascribed to the Lower Micrite.,

3.5.6 THE GRITTY MEMBER.

The Gritty Member averages approximately 1.5 m in thickness, and is uniformly developed throughout the area. It overlies the Upper Micrite member, and is overlain by the Blotchy member. Whilst the lower contact is generally sharp, and defined by the first occurrence of green clay, the upper contact is often more gradational in nature, and somewhat more difficult to pinpoint.

An "upper" Gritty member is occasionally observed within the lower portion of the overlying Blotchy member (Fig. 10). This is typically developed toward the south, over the more central and southern portions of the Barrier Complex. It is not recognized in any of the three cross sections presented in this thesis (Figs. A, B and C, in back pocket), which, crossing only the northern edge of the Barrier Complex, apparently lie a little to the north of its development.

The Gritty Member is characterized by the return of the green clay fraction, such that an overall competent, milky blue-green, dull, earthy, argillaceous limestone is developed. However, the clay component is not nearly so abundandant as in previous intervals, such that the result is more of a dirty limestone, than a marl. Above all, the interval is characterized by two features which, together, lend the rock its "Gritty" texture. Firstly the member contains extremely abundant charophyte oogonia. Secondly, a fine, intraclastic texture is frequently developed.

The charophyte oogonia are generally recognisable as fine white specks. On closer examination, particularly on slabbed surfaces, they appear as small, circular features.

The intraclasts are also fine, generally in the range of 2-6 mm, and are obviously derived locally. They are densely packed, when present, and are a common feature.

The Gritty Member represents a renewed influx of green clay particles into the area. As with both the Upper and Lower Shale members, the significance if this is not fully understood. It also, certainly, represents a period of time when a certain type of green alga was able to flourish. Wiley (1970) stated, of the Class Characeae, that modern genera are found in environments as diverse as "....clear ponds and lakes,....near-shore waters of estuaries, lagoons and tidal ponds, where the influx of fresh, non-saline water is high,.....alpine lakes and hot, alkaline springs." He goes on to suggest a brackish water

environment for their occurrence in the Watt Mountain Formation. Certainly, the elevated salinities suggested up to this point are no longer apparent. Minerals such as gypsum and anhydrite are completely absent.

Continued shallow conditions are envisioned. The relatively discontinuous nature of the unit, its variability from place to place (unique to this interval) and its more prevalent occurrence over the central, and highest portions of the Barrier Complex, all seem to concur with Wiley's shallow, discontinuous, brackish water ponds. This infers shallow water, to shallowly emergent conditions, patchily developed throughout the area, with an adequate freshwater supply, either from increased rainfall or runoff.

3.5.7 THE BLOTCHY MEMBER.

The Blotchy member of the Watt Mountain Formation is, by far, the thickest member, averaging approximately 7.5 m in thickness. It comprises the uppermost member of the formation, and hosts the thin, laterally continuous Amphipora Marker Bed. Whilst its lowermost contact is frequently gradational in nature, its upper contact with the Slave Point Formation is well defined.

Much like the Lower Shale member, the Blotchy member, also, has come to typify the Watt Mountain Formation, at least in the Pine Point region.

The Blotchy member is texturally somewhat variable, but is primarily a fine, dense, micritic limestone, light creamy grey to brownish grey in colour. The interval is particularly striking in appearance, due to the extremely abundant, blotchy features, generally described as reduction mottling, and considered characteristic. Such mottles are medium to dark bluish grey in colour, are ubiquitous throughout the Blotchy member and reflect minor iron sulphide concentrations. This reduction mottling is typically more coarsely developed in the upper half of the interval, above the Amphipora Marker Bed, where it has, somewhat whimsically, been termed "Spitfire texture". Beneath the Marker Bed,

such mottling is fine, densely packed, and distinctly oriented parallel to bedding.

A fine intraclastic texture, similar to that observed within the Gritty member, is occasionally developed here, apparently coinciding with blooms of charophyte oogonia. This textural association is also apparent in the underlying Gritty member.

Rarely, toward the top of the interval, a coarse lithoclastic texture is developed. Such lithoclasts are generally 1.0 cm or less in length, are elongate, and are of unknown provenance. They do, however, show distinct oncolitic rims, 1-2 mm thick.

The Amphipora Marker bed, in itself, is a thin (generally less than 20 cm), regionally continuous unit, which is typically darker brown in colour, and wispier, than the surrounding Blotchy member limestones. The amphipora are abundant, yet matrix supported, nonetheless.

Of all the Watt Mountain members, this uppermost member is interpreted as representing the least restricted of conditions.

Dixon (1976) described identically textured dolomites and dolomitic limestones from western and arctic Canada. He suggested an entirely diagenetic origin for his "patterned carbonate" texture, and limited its occurrence to rocks of an intertidal to supratidal origin.

A diagenetic origin for the "blotchy" texture found within the Watt Mountain Formation is acceptable. However, it is believed to more specifically represent the diagenetic enhancement of certain pre-existing textures. Such textures may well be of diverse origin, but are believed, in part at least, to represent bioturbation.This would indicate that certain soft bodied organisms, not otherwise preserved, were able to flourish at this time. In this context, the charophyte rich intervals, with associated intraclastic material, would seem to represent periods of somewhat shallower conditions. Such interbeds, together with interbeds of the Gritty member reported farther to the south, suggest that depth conditions fluctuated throughout this time, particularly during "early Blotchy time".

Toward the end of Watt Mountain time conditions had clearly become more normal, shallow marine in character, with a slightly more diverse fauna.

3.6 Summary - History of Deposition

During the active growth of the Pine Point Barrier Complex, (Pine Point and "Lower" Sulphur Point time), coeval marine facies were developed north, and seaward, of the Barrier Complex. The nature of the sediment comprising this marine facies development is indicative of strongly euxinic conditions. This is evidenced, primarily, by the extremely high percentage of preserved organic material within these marine facies, and within F facies in particular. The fine, planar laminated, and undisturbed character of the sediment further indicates calm, stagnant bottom conditions.

Considering the estimated basinal slope of the Barrier Complex, F facies was certainly not deposited in deep water. It would seem doubtful that water depths ever exceeded 150 m, whilst depths as shallow as 30 m are not unlikely.

The onset of Buffalo River sedimentation indicates a period of time when bottom conditions became considerably more oxygenated. This is evidenced by both the greater diversity of fauna, and the highly bioturbated nature of the sediment. The presence of a grey clay fraction within this sediment, also indicates the onset of a terrigenous influx into the basin at this time. Such newly oxygenated conditions, as evidenced by G–B lithofacies, would also, presumably, reduce organic preservation potential considerably.

This initial Buffalo River sedimentation is believed to have occurred subsequent to a marine regression, which resulted in exposure of the Pine Point Barrier Complex (Fig. 11a). The improved oxygenated conditions may well have been a direct result of this regressive phase. Nevertheless, no drastic drop in water depth is envisioned, for whilst such a regression would have caused conditions seaward of the Barrier Complex to have shallowed somewhat, the

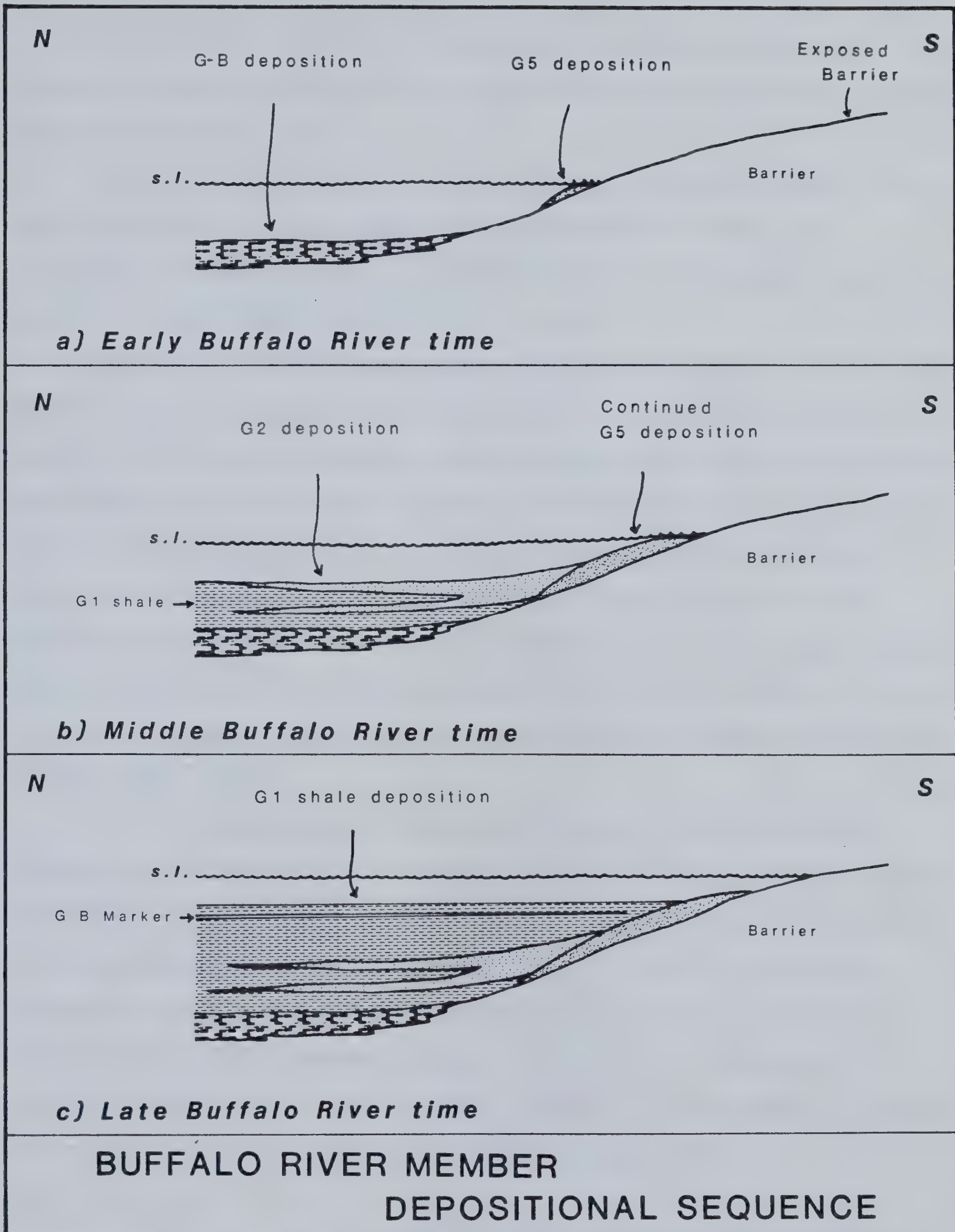

Figure 11. Sequence of cartoons, illustrating Buffalo River Member deposition.

drop in sea level, necessary to expose the Barrier Complex, need only have been in the order of a few metres.

G–B lithofacies, therefore, is interpreted as being deposited under oxygenated, marine conditions, to the north, and seaward, of the newly exposed Barrier Complex (Fig. 11a).

G5 lithofacies deposition is also believed to have been initiated at this time. Its deposition is interpreted as being the result of erosion and redeposition of Barrier Complex (carbonate) sands, in wave agitated waters fringing the Buffalo River sea (Fig. 11a).

As such, G5 lithofacies presumably rests unconformably on the underlying Barrier Complex facies. The unconformable nature of this contact is indicated, primarily, by the sharp crystallinity break observed at this point. The spectacular dolomitization, or "Presqu'ilization", which prevails throughout the upper portion of the Barrier Complex, and affects both the Pine Point and the "Lower" Sulphur Point formations, stops abruptly at this contact (Fig. 8). A similar crystallinity break is also observed at the contact between the "Lower" Sulphur Point Formation, and the overlying Watt Mountain Formation, farther to the south and this is a contact which has long been recognised as being unconformable in nature (Skall, 1975).

Of further significance is that the northernmost extension of this "Presqu'ile" development can be recognised as being broadly coincident with the northernmost development of the overlying G5 lithofacies (Fig. 8). Inasmuch as this recrystallization phenomena is believed to have occurred during the sub–aerial exposure of the Barrier Complex, and insofar as its distribution should, thereby, reflect palaeo–hydrologic conditions at this time, then this coincident distribution becomes particularly significant. It would seem to, in some way, reflect sea–levels at the point of maximum regression, early in Buffalo River time.

G5 lithofacies, then, is believed to be a diachronous unit, prograding southward with time, as the Buffalo River sea gradually encroached upon the Barrier Complex, and as the area to the north continued to fill with sediment

(Fig. 11b).

Calcareous shales of the G1 lithofacies dominated Buffalo River sedimentation during this steady transgression of the Barrier Complex. The paucity of benthonic fauna, within this interval, is strongly suggestive of inhospitable bottom conditions. This, however, cannot be attributed to any great depth of water, for there is no evidence to suggest anything but the same shallow conditions with which Buffalo River time began.

The dominant contributing factor, to such hostile conditions, may well simply have been the ingression of clay into the environment, proving inimicable to many life forms. Whether this resulted in rapid sedimentation rates, or high turbidity conditions, or some other unknown effect, can only be speculated upon. In any event, such conditions were maintained almost throughout Buffalo River time, broken only by the deposition of three distinct marker horizons, represented by the G2 nodular argillaceous limestone (Fig. 11b), and the G B Marker bed (Fig. 11c).

G2 lithofacies marks two distinct periods of time when argillaceous supply was somewhat reduced, and submarine hard layers were developed. Conditions apparently remained largely inhospitable to life, throughout both these periods, a factor which may well account for the absence of boring organisms.

The G B Marker bed, on the other hand, marks the sudden, and complete, cessation of terrigenous supply to the area. The reason for this intermission cannot be determined from the study area, but the period can be viewed as a prelude to environmental conditions to come, in "Upper" Sulphur Point time.

Once again, water depths are not believed to have changed to any significant degree. Rather, the respite from argillaceous influx, in itself, appears to have allowed for carbonate production, otherwise inhibited.

At the end of Buffalo River time, after a short period of renewed shale deposition (Fig 11c), argillaceous supply was, again, suddenly withdrawn, such that carbonate production was once more possible. Throughout Buffalo River time, the marine transgression had apparently kept apace with sedimentation,

such that water depths remained fairly constant.

By early "Upper" Sulphur Point time, the entire Barrier Complex may well have been shallowly inundated, although the exact extent of the transgression cannot be determined. Certainly, environmental conditions were such that a fringing reef was able to develop on the northern edge of the shallowly, (and perhaps only partially), submerged Barrier, in what must have been warm, clear waters. Seaward of this presumably high energy zone, coeval marine carbonates were developed (B Biostromal facies) in water that was still shallow, but probably only slightly agitated (Fig. 12a).

By mid "Upper" Sulphur Point time another marine regression occurred, resulting, once more, in the sub-aerial exposure of both the Pine Point Barrier Complex, and the recently deposited Reefal facies of the "Upper" Sulphur Point Formation.

It is difficult to ascertain just how much of "Upper" Sulphur Point Formation sediment was removed during this partial hiatus. Certainly some reefal material was lost, and if any sediment had been deposited south of this reefal zone, it, too, must have been removed at this time, and removed without trace.

To the north, however, sedimentation continued uninterrupted, as the shallow marine carbonate conditions, of B Biostromal facies, gave way to the even shallower conditions evidenced by the Restricted facies (Fig. 12b). Once more, the drop in sea level, required to produce this regressive phase, need only have been in the order of a few metres.

At the onset of Watt Mountain time, sub-aerial exposure of both the Barrier Complex and its fringing sediment continued, whilst to the north sedimentation continued, uninterrupted (Fig. 13a). Nevertheless, by relatively early in Watt Mountain time, a shallow transgression, of regional extent, had occurred. (A transgression which had, in fact, begun late in "Upper" Sulphur Point time.)

The sediment filling of the area north of the Barrier Complex, which had virtually been achieved by the end of Buffalo River time, was completed by early Watt Mountain time. In this way extensive, layer-cake like sedimentation was able to take place, on an essentially horizontal depositional surface.

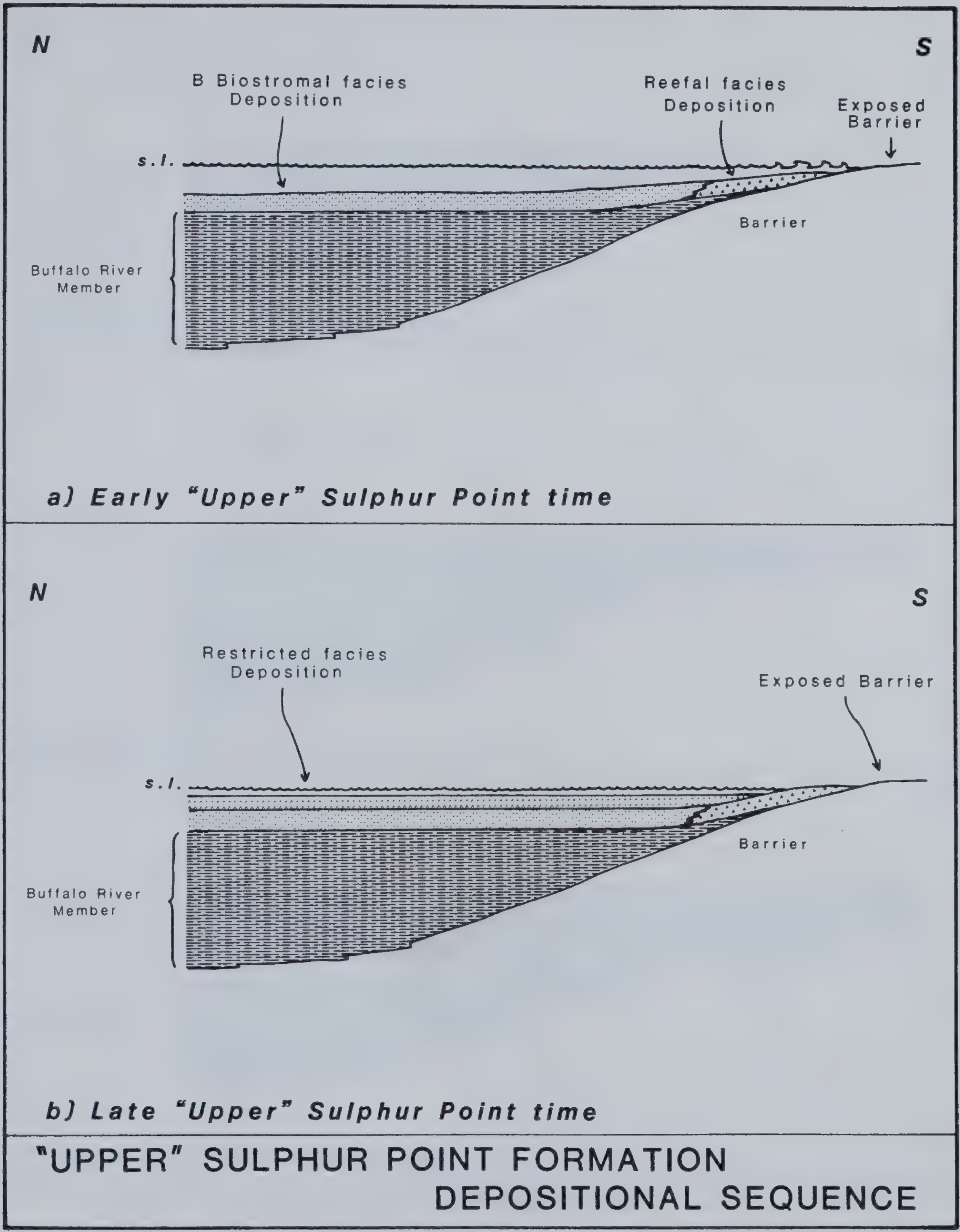

Figure 12. Sequence of cartoons, illustrating "Upper" Sulphur Point Formation deposition.

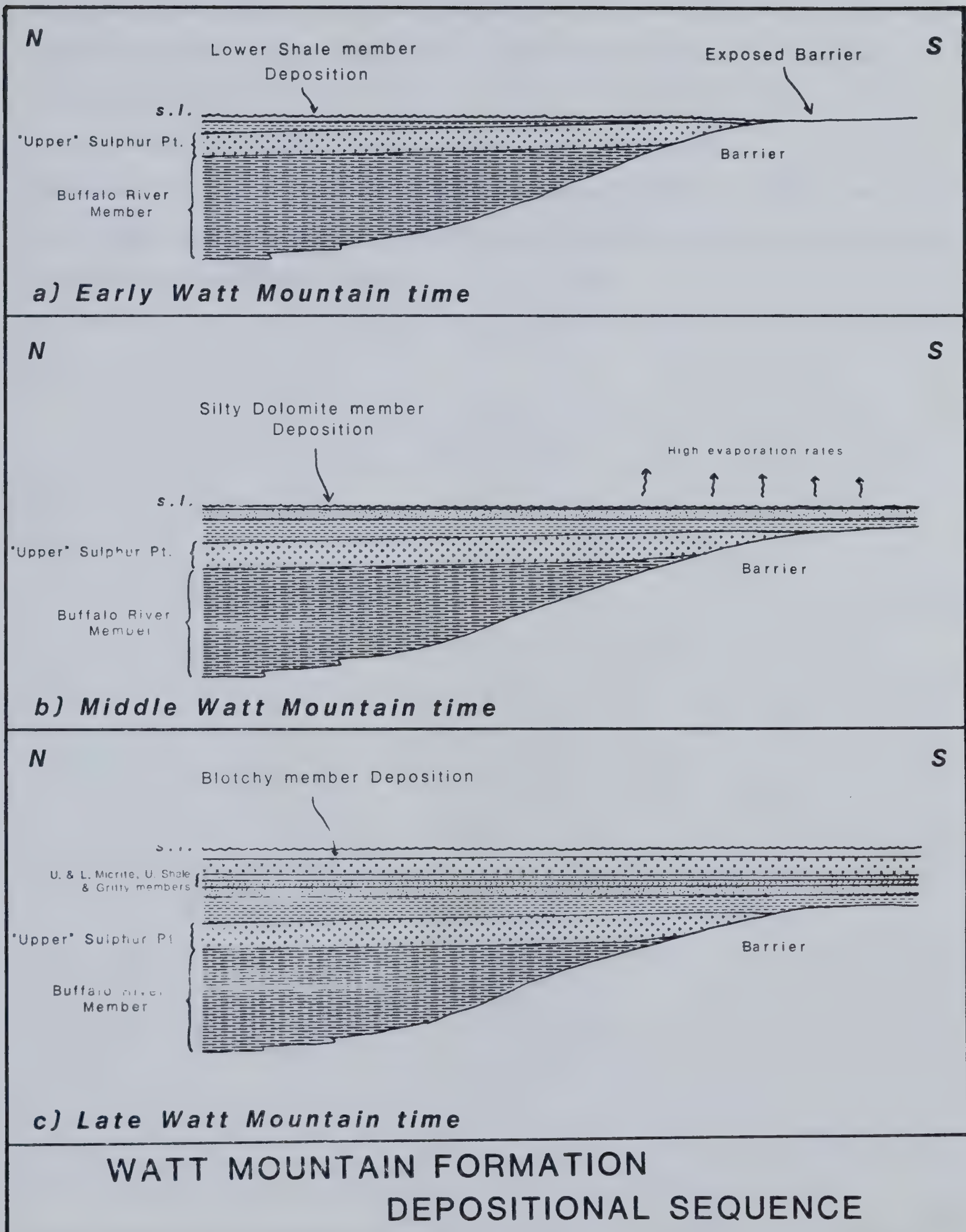

Figure 13. Sequence of cartoons, illustrating Watt Mountain Formation deposition.

Extremely shallow and restricted conditions persisted throughout Watt Mountain time (Fig. 13b). However, by the end of this period less restricted, and more open marine conditions, had started to prevail (Fig. 13c), such that by early Amco time a fairly diverse fauna was once more able to flourish.

Whilst of a greatly more specific nature, the overall regressive–transgressive picture presented here is broadly in keeping with the more global picture presented by Lenz (1982), in his study of sea–level changes in western and northern Canada.

4. BIOSTRATIGRAPHY AND PALAEOECOLOGY

Processing of thirty six samples from the study area resulted in only nineteen productive intervals, more or less restricted to the Buffalo River Member (sixteen samples, fifteen productive) and the F and B (marine) facies of the Pine Point Formation (three samples, all productive). No conodonts were recovered from either the "Upper" Sulphur Point or Watt Mountain formations (one sample and thirteen samples respectively). One sample from the M3 facies of the Amco Member, Slave Point Formation, also proved productive, out of the three processed.

Whilst nineteen samples contained conodonts, yields were generally extremely low. The only exception to this rule was the marine carbonate to shale, transitional interval, G–B lithofacies, which not only contained a more abundant fauna, but also contained numerous conodont pearls.

The location of both productive and non-productive samples is indicated on the appropriate geologic cross-sections (Figs. A and B, in back pocket). Conodont distributions within these productive zones are diagrammatically illustrated in Fig.14.

Conodont faunas are, on the whole, of relatively low diversity.

Polygnathus linguiformis linguiformis forma gamma (Bultynck, 1970) is the most conspicuous species, occurring, more or less, throughout the sequence, with the notable exception of the G B Marker Bed and M3 facies.

Species of the *varcus* group are similarly ubiquitous. Both *Polygnathus ansatus* (Ziegler et al., 1976) and *Polygnathus timorensis* (Klapper et al., 1970) can be recognized. However, many specimens can only be satisfactorily placed in the broader *Polygnathus varcus* (Stauffer) group, which includes these two species and *P. varcus.* The accepted criteria for separating the species of this group proved to be somewhat difficult to apply, particularly to immature specimens. Orchard (1978) made this same observation, suggesting that *P. timorensis* and *P. varcus* might represent intraspecific variants of one natural

FORMATION	Member	Litho-facies	Sample #	*Polygnathus linguiformis linguiformis* γ	*Polygnathus linguiformis linguiformis* δ	*Polygnathus ansatus*	*Polygnathus alveolipostícus*	*Polygnathus* aff. *P. dubius*	*Ozarkodina insita*	*Icriodus difficilis*	*Polygnathus timorensis*	*Polygnathus xylus ensensis*	*Polygnathus linguiformis linguiformis* ε	*Icriodus brevis*	*Polygnathus varcus* group	*Icriodus nodosus*	*Polygnathus* aff. *P. brevilaminus*	CONODONT ZONATION Ziegler et al 1976
SLAVE POINT FM.	AMCO MEMBER	M3	3002														✓	Upper **varcus**-Subzone
PINE POINT FORMATION	BUFFALO RIVER MEMBER	G B Marker	3032							✓	✓	✓		✓	✓			Middle **varcus**-Subzone
			3021								✓	✓		✓		✓		
			3027							✓				✓	✓			
		Upper G2	3048	✓											✓			
			3042	✓											✓			
			3034												✓			
			3022	✓						✓					✓			
			3028	✓							✓			✓	✓			
		Lower G2	3049	✓							✓			✓	✓			
			3041	✓										✓				
			3029	✓										✓				
		Lowest G1	3036							✓								
			3037	✓	✓			✓		✓		✓		✓				
		G-B	3043	✓	✓					✓		✓	✓					
			3030	✓		✓	✓	✓	✓	✓	✓							
	NOT ASSIGNED	B (marine)	3038	✓		✓												
			3031	✓		✓												
		F	3023	✓	✓													

Figure 14. Summary of conodont distribution, north of Pine Point Barrier Complex.

species. Because of this close morphological relationship, Ziegler et al. (1976) suggested that *P. ansatus* was derived from *P. timorensis.* They further pointed out that juvenile forms of these species are indistinguishable: *Polygnathus rhenanus* (Klapper et al., 1970) is now regarded as a junior synonym of *P. timorensis* since it is believed to be one of these juveniles. These two species have considerably overlapping ranges (Klapper et al., 1970).

For the purposes of this study, therefore, specimens of this nature have simply been placed in the *varcus* group.

One specimen of *Polygnathus alveoliposticus* (Orr & Klapper, 1968) was identified. Ziegler et al. (1976) noted of this form that its first appearance, in New York, is coincident with that of *P. ansatus.*

Polygnathus xylus ensensis (Ziegler et al., 1976), *Polygnathus linguiformis linguiformis* forma epsilon (Bultynck) and *Icriodus nodosus* sensu lato (Huddle) occur in limited numbers. *Icriodus difficilis* (Ziegler et al.) and *Icriodus brevis* (Stauffer) can also be found throughout the Buffalo River sequence.

Middle varcus-Subzone.

The lower boundary of the Middle *varcus*–Subzone, as defined by Ziegler et al. (1976), is based on the first occurrence of *Polygnathus ansatus,* and its upper boundary is defined by the first appearance of *Polygnathus latifossatus.* Both *P. ansatus* and *Polygnathus linguiformis linguiformis* forma delta are restricted to this Middle *varcus*–Subzone.

All samples collected from the Pine Point Formation, including the Buffalo River Member, appear to belong to this Middle *varcus*–Subzone. All samples from G–B lithofacies (the oldest Buffalo River interval), and underlying F and B (marine) facies, contain the zone species *P. ansatus* and *P. linguiformis linguiformis* forma delta. Samples from stratigraphically younger horizons, however, were not found to contain these forms. On the other hand, neither were they found to contain conodonts indicative of the Upper *varcus*–Subzone.

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On the basis of this, admittedly rather negative evidence, the entire Buffalo River sequence is placed in the Middle *varcus*–Subzone.

This corresponds to a late-middle Givetian age, and results in correlation of the Buffalo River Member with the Dawson Bay Formation of S. W. Manitoba (Norris et al., 1982), with the Ramparts Formation of Powell Creek, District of Mackenzie (Uyeno, 1979) and the upper Hare Indian shales of the Mackenzie Mountains (Chatterton, 1979).

This same zone can be recognized in the Devonian of southwest England, where Orchard (1978) recorded a conodont assemblage including both *P. ansatus* and *P. linguiformis linguiformis* forma delta. He referred to it as Fauna 8, which he correlated with the lower part of the middle Givetian (Orchard, 1978, Text fig. 2). Conodonts from the Horn Plateau Formation reefs of Fawn Lake, southern N.W.T., have been placed in the broad *Polygnathus varcus* zone and a Givetian age thus assigned (Fuller & Pollock, 1972). On the basis of information available, further subdivision is difficult.

Upper varcus-Subzone.

Ziegler et al. (1976) defined the lower boundary of the Upper *varcus*–Subzone by the first occurrence of *Polygnathus latifossatus. Ozarkodina sannemanni* also appears, for the first time, within this zone.

None of these forms are present in the Pine Point samples. However *Polygnathus* aff. *P. brevilaminus* (Branson) is found in the M3 facies of the Amco Member, at the very base of the Slave Point Formation. Uyeno, in Norris et al., 1982, has referred similar forms to *P. brevilaminus.* This would place the sample above the Middle *varcus*–Subzone, most probably within the Upper *varcus*–Subzone, and, thereby, in the late Givetian.

The lower Slave Point Formation would thus correlate with the "First Red" and Argillaceous Limestone members of the Souris River Formation of S. W. Manitoba. Uyeno (in Norris et al.,1982) has illustrated the same taxon and

identified *P. brevilaminus* from the Souris River. Norris et al. placed this part of the Souris River in the upper Givetian. The Upper *varcus*-Subzone is also recognized in the Devonian of southwest England, although *P. brevilaminus* has not been identified.

P. brevilaminus is found in Upper Devonian strata of the Waterways Formation (Uyeno, 1974) and, as such, is fairly wide ranging.

In conclusion, then, a late-middle to late Givetian age is indicated for the Buffalo River - "Upper" Sulphur Point - Watt Mountain sequence.

Unfortunately, no conodont data are available from the Barrier Complex, and the nature of the constituent barrier facies makes successful conodont collection unlikely. Nevertheless, a Middle Givetian age is generally attributed to the Pine Point Barrier Complex, on the basis, primarily, of ostracod assemblages (Skall, 1975).

Conodont sampling of the Buffalo River to Watt Mountain sequence, therefore, indicates that sediment filling the shelf area north of the Pine Point Barrier Complex could well be younger than the Barrier Complex, as is also suggested by the stratigraphic relationships discussed elsewhere in this work.

Palaeoecology.

The *Polygnathus-Icriodus* dominated fauna within the Buffalo River Member is believed to be indicative of shallow open marine deposition (Chatterton, 1975).

The relatively poor conodont yield, from most samples, is most likely a function of rapid sedimentation rates, effectively diluting conodont numbers. The exception to this rule is the basal G-B lithofacies, which contained significantly greater numbers of conodonts. This is also believed to relate to sedimentation rates, which, prior to the onset of terrigenous influx into the basin, are believed to have been extremely slow.

The apparent absence of conodonts from the "Upper" Sulphur Point Formation is presumably a function of

1) Inhospitality of a reefal / stomatoporoid facies environment to the conodont animal (a general observation made by several workers, including Seddon, 1970, and Chatterton, pers. comm.) and

2) Sampling difficulties relating to the extensive fine grained dolomitization of the B Biostromal facies.

The total absence of conodonts from the Watt Mountain Formation is also believed to relate directly to environmental conditions, which were, presumably, at all times sufficiently restricted to constrain conodont existence.

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Appendix A

DRILL LOGS

Note:

The drill logs presented here are the result of relogging the three fences of diamond drill holes, used to document this thesis, during the summer of 1982.

The lithofacies breakdown used herein is in keeping with the breakdown developed by Pine Point Mines Ltd. geologists.

In this regard, the "Upper" Sulphur Point Formation (of this thesis) is referred to, here, as the B Biostromal "Formation". This term encompasses both the B Biostromal facies and the Reefal facies. The restricted facies of the "Upper" Sulphur Point Formation is referred to, in these logs, as the Basal Marine member of the Watt Mountain Formation.

The term G3 lithofacies refers to a Buffalo River Member subdivision which was not adopted in this thesis. Furthermore, within these logs, the Buffalo River Member of the Pine Point Formation is referred to as the Buffalo River "Formation".

Cominco D.D.H. 4323

0 - 29.3 Casing/Overburden.

29.3 - 36.9 SLAVE POINT FORMATION.

29.3 - 31.8 N Facies. *Variable sequence of limestones.*

31.8 - 36.9 Amco Member.

31.8 - 32.8 M2 (Upper Amco)? *Fossiliferous limestone.*

Somewhat transitional zone with overlying N Facies.

32.8 - 35.1 M1 (Amco Shale). *Marl.*

Fairly typical - dull, earthy, quite competent, medium grey limy marl. Quite uniform throughout: upper half, especially, has a vaguely bioturbated texture, and contains rare, scattered, crinoidal debris. The lowermost 30 cm of this unit contains thick - shelled brachiopod debris - disarticulated for the most part - and associated with a more intraclastic matrix, especially toward the base.

35.1 - 36.9 M3 (Lower Amco)*Fossiliferous limestone.*

Another typical unit. Pinkish - grey, bulbous stromatoporoids (poorly sorted, abraded/broken in part, and showing oncolitic rims) are hosted by a coffee brown, wispily argillaceous, matrix. Wisps are clearly seen to horsetail about fossils.

36.9 - 75.0 WATT MOUNTAIN FORMATION.

36.9 - 46.3 Blotchy Member. *Limestone.*

Thick sequence of limestone, divisible into an upper and lower half, as follows:

36.9 - 42.4 Upper Blotchy - overall finely bedded characte (finely vuggy, enhancing bedding) with a fine, elongate, reduction mottling developed throughout. A distinctly intraclastic texture is developed

to 39.0

42.4 – 42.5 Amphipora Marker Bed. *Amphipora floatstone.*

Poorly developed here.

42.5 – 46.3 Lower Blotchy – typical, dense, competent, fine limestone, with abundant, coarse reduction mottles. Unit has an overall grey brown colour.

46.3 – 48.0 Gritty Member. *Argillaceous limestone.*

Typical, intraclastic, (clean, light grey) limestone, overlying a progressively greener, more argillaceous, unit – approaching a marl – with vague reduction mottles, and hosting charophyta.

48.0 – 50.6 Upper Micrite. *Micritic limestone.*

A beautiful example: light cream in colour, dense, stylolitic in part, with a characteristic fine, cellular style vugginess.

50.6 – 52.9 Upper Shale. *Limy and dolomitic shales and marls.*

Typical, heterogeneous sequence of green shale and dull, earthy dolomitic marl, sandwiched by an upper lithoclastic unit – limy, richly argillaceous, and hosting charophyta (to 51.1 m) and a lower, more marbled textured unit – dolomitic, but becoming limy toward base.

52.9 – 54.3 Lower Micrite. *Micritic limestone.*

Dense, light creamy limestone – stylolitic,occassional green clay wisps, with a wispy, charophyta rich interbed 53.3 – 53.5

54.3 – 59.7 Silty Dolomite Member? *Fine grained dolomite.*

54.3 – 54.9 Wispily argillaceous – vaguely gritty – distinctly green.

54.9 – 58.2 Medium brown, finely bedded in part, porous limestone?? Characteristic sandy/porous texture – poss. calcite flooded dolomite??

58.2 – 59.7 More typical example light brown, silty, porous dolomite. (Last 30 cm marbled with gypsum, to give a partially laminated, chicken – wire texture.)

59.7 – 69.5 Lower Shales. *Limy and dolomitic shales and marls.*

(dol. 59.7 – 65.8, lmst. 65.8 – 66.3, dol. 66.3 – 71.9) Fairly complex, heterogeneous sequence of green shales and marls; cleaner,

but earthy, light coffee coloured dolomites; and clean micrites. Green shaly material is frequently finely laminated with a browner dolomite, to give an almost varve – like texture.

N.B. 62.8 – 63.1 Abundant gypsum produces an overall nodular texture with displaced green shale highlighting a coarse chicken wire texture.

69.5 – 75.0 Basal Marine Member. *Sparse biomicrite.*

Very difficult to pick base here. Unit is dolomitic to 71.9 m Extremely well developed here: a medium coffee brown colour predominates. Unit is wispily laminated in part–especially upper half –where it is texturally similar to overlying unit. The characteristic mottled, or burrowed, texture is not widely developed here. Toward base unit becomes darker, more abundantly argillaceous, with a fine flaser texture developed in part. Fine white specks are abundant toward base, reminiscent of charophyta??? or extremely fine amphipora??? Their presence straddles the contact with B Biostromal.

75.0 – 80.5 B BIOSTROMAL "FORMATION." *Fossiliferous dolomite.*

(Lmst/dol contact @75.6m) Majority of unit is dolomitic. More or less unfossiliferous to 77.1 m, and very similar to overlying Basal Marine member – slightly darker brown in colour. The transition to a richly fossiliferous, 'biostromal' unit is extremely sharp – wherein tabular stromatoporoids, corals, ?digitate stromatoporoids?, and thick brachiopods become extremely abundant. Overall this unit is lighter than is considered normal. Basal contact with G extremely sharp.

80.5 – 115.5 BUFFALO RIVER "FORMATION".

80.5 – 82.9 G1 Shale. *Dolomitic shale.*

Soft, fissile, med. greenish grey, dolomitic shale. Extremely fissile – otherwise featureless.

82.9 – 84.0 G B Marker Bed. *Limestone.*

Quite typical, B Biostromal like, brown limestone. Dark chocolate brown for the most part, with abundant, elongate, 'nodules' or 'clasts' of G1 material - more or less throughout. There is a central area of more abundant G1 shaly material here.

84.0 - 95.4 G1 Shale. *Limy shale.*

Extremely fissile, uniform, and rather uninteresting. Rare crinoidal debris toward top, with rare, thick shelled, ribbed, brachiopods - articulate in general. Unit is finely pyritic on the whole.

The uppermost 1.5 m is slightly more competent, and has a distinctly nodular texture. This grades transitionally down into the more fissile material.

95.4 - 97.1 G2 *Nodular argillaceous limestone.*

Distinctly, and sharply more competent unit. Medium/light brown in colour, with large, lighter, grey - brown nodules (hosting a gastropod?). Rare scattered crinoidal debris, especially toward base.

97.1 - 101.6 G1 Shale. *Limy shale.*

Med grey, fissile, pyritic, limy shale: quite typical.

101.6 - 102.7 G2 *Nodular argillaceous limestone.*

More or less identical to G2 above.

102.7 - 109.7 G1 Shale. *Limy shale.*

Strongly pyritic, extremely fissile shale, with occassional thin interbeds of underlying material (@107.1 - 107.3, @109.1 (5 cm only) and @ 109.4)

109.7 - 111.6 G - B *Limestone.*

Very striking unit, with a strong, coarse, mottled texture -reflecting strong bioturbation? Unit is limy to 111.1, remainder is dolomitic. There is some thin shelled brachiopod debris here also. Small pyritic nodules persist

111.6 - 115.5 G - B *Dolomitized?*

Somewhat atypical, medium grey, sandy dolomite. Uniform for the most part - although uppermost 30 cm may contain ghost

megafossils.

114.9 - 115.5 Strongly recrystallized bed. White dolspar impregnated to give a patchy, pseudo-brecciated texture. Basal contact is extremely sharp, and only approx. upper 50 cm of underlying B Marine/ F facies is dolomitized.

115.5 - 191.1 PINE POINT FORMATION.

115.5 - 120.7 B Marine Limestone. *Biomicrite.*

(Uppermost 50 cm dolomitized. 118.9 - 119.8 also dolomitized.) Hosts numerous F like interbeds. Overall this is a med. greyish brown unit, hosting thin bluish grey brachiopods, lesser crinoids, and abundant tentaculites in more F like interbeds.

120.7 - ? F Facies. *Biomicrite.*

Dark brown, petroliferous limestone, hosting abundant tentaculites. Occassional B Marine like interbeds.

F and B Marine continue to alternate to approx. 175.3 m

Hole continues to 195 m (within Keg River Formation) - not logged at this time.

Cominco D.D.H. 4322

0 - 27.1 Casing / Overburden

27.1 - 36.6 SLAVE POINT FORMATION.

27.1 - 32.0 N Facies. *Variable sequence of limestones.*

32.0 - 36.6 Amco Member.

(No Upper Amco?? Possibly 31.7 - 32.0??)

32.0 - 35.4 M1 (Amco Shale).*Marl.*

Medium grey, dull earthy marl; fairly competent. Limy from 32.5 m onward. Fairly large pinkish white crinoid ossicles are scattered rarely throughout. Scatterings of broken and disarticulated, thin-shelled brachiopods appear toward base. Last 30 cm is distinctly transitional with Lower Amco becoming browner, and strongly bioturbated.

35.4 - 36.6 M3 (Lower Amco). *Fossiliferous limestone.*

Uppermost 30 cm quite richly crinoidal, and strongly bioturbated. Thin shelled brachiopod debris is also present. Some large finger-like burrows are also visible. This unit is apparently transitional into underlying 'true' M3 a coffee brown, dense limestone, with abundant pinkish bulbous stromatoporoids, showing well developed oncolitic rims. One gastropod is also clearly identifiable. Such macro-fossils occur within a wispily argillaceous, finely bioclastic matrix. Approximately 20 - 25% of the unit is bulbous stromatoporoid.

36.6 - 68.3 WATT MOUNTAIN FORMATION.

36.6 - 45.9 Blotchy Member. *Limestone.*

Very well developed - quite typical.

36.6 - 41.5 Upper Blotchy - finely laminated to finely for the most

part, with abundant, characteristic, fine reduction mottles developed throughout (elongate parallel to bedding). Interbeds of distinctly intraclastic material occur sporadically – especially around 39.6 m A fine cellular vugginess – generally elongate parallel to bedding – is occassionally developed.

41.5 – 41.9 Amphipora Marker Bed. *Amphipora floatstone.*

Quite typical, dense, light coffee brown limestone, with abundant amphipora, and lesser bulbous stromatoporoids – often leached to give a fossil moldic vugginess. Fossils are abundant, and densely packed.

41.9 – 45.9 Lower Blotchy – another typical sequence of coarsely (and boldly) reduction mottled, dense, brownish grey limestones and *dolomites* (42.1 – 45.1). Unit is somewhat more earthy than usual – more crypto – crystalline possibly? Porous in part, distinctly bioturbated in part.

45.9 – 47.5 Gritty Member. *Argillaceous limestones.*

Again, well developed interval of finely bedded, intraclastic, wispy argillaceous limestones – possibly containing abundant charophyta – with denser, more competent, cleaner intraclastic beds.

47.5 – 49.2 Upper Micrite. *Micritic limestone.*

Light, creamy beige, fine dense limestone. Fine vugginess sporadically developed: minor stylolites. Typical.

49.2 – 50.9 Upper Shale. *Limy and dolomitic shales and marls.*

Heterogeneous sequence of green shales (soft and fissile), green marls (dull and chalky), intraclastic and 'marbly' textured mixtures of above. Unit is dolomitic from 49.7 m on, and from 50.3 m onward is cleaner, greyer, almost earthy in texture, reduction mottled, with minor green shale wisps. A few cm of green shale mark the base.

50.9 – 52.1 Lower Micrite. *Micritic limestone.* Virtually identical to Upper Micrite, described previously. A fine motheaten style of vugginess is developed throughout.

52.1 - 52.9 *Dolomitized* Lower Micrite?? Dense, faintly reduction mottled, medium grey brown

52.9 - 57.0 Silty Dolomite Member. *Fine grained dolomite.*

Dull, creamy brown, finely laminated, porous dolomite. Brecciated texture developed in part - especially 56.7 - 57.0 - evidence of intrastratal collapse, probably the result of evaporite dissolution. (Recovery within this unit is characteristically poor.)

57.0 - 64.9 Lower Shale. *Limy and dolomitic shales and marls.*

Heterogeneous sequence of green shales, marls, and cleaner limestones and dolomites - generally dull and earthy in texture. The latter are frequently interbedded in a 'marbled' mannner - occassionally more intraclastic in texture. Unit is dolomitic in upper half, limy from 61.6 m on.

64.9 - 68.3 Basal Marine Member. *Limestone.*

Predominantly a light creamy brown, fine, dense, limestone. Creamy beige at the top, the unit becomes progressively darker with depth. To approx 67.0 m unit is riddled with elongate vugs (leached version of blebby texture usually encountered - possibly representative of burrows or bioturbation?) Unit is wispily argillaceous in part, but rarely so in upper half, becoming more so from 67.0 m on.

The base of this unit is very difficult to pick, as the interval 68.3 - 69.8 is strongly recrystallized.

N.B. A 2.5 cm brown limy clay seam occurs at what is clearly *not* the base of the Watt Mountain Formation

68.3 - 73.9 B BIOSTROMAL "FORMATION". *Fossiliferous dolomite.*

68.3 - 69.8 Possible transitional interval? Strongly recrystallized to a 'salt and peppery', white dolspar flecked, dark brown, (argillaceous) dolomite.

69.8 - 73.9 More or less typical, medium to dk brown, dense, finely silty to crystalline, wispy dolomite, with a fine mottled, bioturbated texture developed throughout. Scattered fossil debris again occurs more or less

throughout especially slender digitate stromatoporoids/or corals, with minor thick - shelled brachiopods

73.9 - 87.3 BUFFALO RIVER FORMATION.

73.9 - 75.4 G1 Shale. *Dolomitic shale.*

Extremely fissile, dolomitic shale. Upper contact is extremely sharp - however, uppermost 15 cm here is more competent and shows evidence of bioturbation.

75.4 - 75.9 G B Marker Bed. *Dolomite.*

Typical dense, brown, finely crystalline dolomite - identical to overlying B Bio 'matrix' material.

75.9 78.9 G1 Shale. *Limy shale.*

Extremely fissile, medium greenish grey, limy shale - pyritic/marcassitic throughout. Macro-fossils rare (one coral fragment).

78.9 - 80.5 G2 *Nodular argillaceous limestone.*

Fairly competent, nodular, argillaceous limestone (dolomitized 79.3 - 80.3). Nodules are quite discrete, light grey in colour, vaguely micritic, within a much darker grey, wispy, pyritic matrix. Argillaceous wisps splay about nodules. Within dolomitized portion, nodules take on a distinctly sandy texture. Macro-fossils are rare to absent - there are possibly some crinoid ossicles and minor thick-shelled brachiopod debris (all very rare).

80.5 - 82.3 G1 Shale? *Limy shale.*

Predominantly a medium greenish grey, fissile, limy shale - however here hosting numerous 5.0 - 7.5 cm interbeds of G3 like material (more competent, and strongly mottled in texture, suggestive of bioturbation). i.e. 80.6 - 80.8 (also hosting coralline debris) and 80.9 and 81.2 are best developed examples.

82.3 - 83.8 G2 *Nodular argillaceous dolomite.*

The nodular "macro" - texture persists however the dolomitization effectively alters much of the finer textural detail.

83.8 – 85.3 G1 Shale. *Limy and dolomitic shales and richly argillaceous limestones.*

83.3 – 84.1 Competent, strongly mottled dolomite. Distinctly bioturbated in aspect.

84.1 – 84.9 Soft, fissile, limy shale, enclosing a 15 cm G3'ish interbed 84.6 – 84.75.

84.9 – 85.3 Dolomitic. Strong mottled, bioturbated texture.

85.3 – 86.6 G2 *Nodular argillaceous dolomite.*

Otherwise typical. Scattered rare crinoidal debris throughout.

86.6 – 87.3 *Argillaceous dolomite.*

Somewhat unusual interval, medium grey, quite dense, very finely sandy in texture – very faintly mottled –possibly a dolomitized G3.

N.B. Base here is quite strange – and very sharp against underlying KE. A clay band is recovered at the contact, with numerous sub – angular pebbles (0.5 cm diameter) embedded within it. Pebbles are apparently of overlying material. This would appear to be some sort of recent karst related phenomena??

87.3 – (E.O.H.) PINE POINT FORMATION.

87.3 – 109.4 E Facies. *Dolomite.*

Light/med brown, somewhat darker than usual for the most part, generally "sandy" textured dolomite. Wisps are extremely rare. Minor fossil moldic vugs (thick brachiopods especially)

109.4 – 110.6 B – E Facies. *Wispy dolomite.*

Med grey brown, dense dolomite, hosting abundant, thin – shelled brachiopods

110.6 – 112.7 E Facies. *Dolomite.*

As above – dense.

112.7 – 113.1 B Marine Dolomite. *Dolomitized biomicrite.*

Abundant thin-shelled brachiopods and crinoids, in a dense wispy matrix.

113.1 - 130.2 F Facies.*Fossiliferous micrite.*

(dolomitic in part but lmst. from 113.7 on.) Typical dark brown, dense, planar laminated, tentaculites rich limestone.

118.0 - 121.6 TURC?

E like dolomite - coarsely sandy, but with coarse abraded fossil debris - some kind of debris flow?

129.5 - 130.2 TURC? Coarse crinoidal limestone. Light creamy brown in colour - possibly introduced (older) material?

N.B. Hole continues to over 198 m - not logged at this time.

Cominco D.D.H. 4321

0 – 11.3 Casing/Overburden.

11.3 – 32.5 SLAVE POINT FORMATION.

11.3 – 18.0 O Facies. *Variable sequence of limestone.*

18.0 – 28.0 N Facies. *Variable sequence of limestone and dolomite.*

28.0 – 32.5 Amco Member.

28.0 – 28.7 *Limestone.*

Somewhat transitional unit – difficult to define precisely. Distinctly different from overlying Spitfire-textured N Facies. However, this is not typical M2 – neither is it precisely M1. Unit is medium brown grey, probably a dolomitic limestone, with a vague pelletal texture, and a mottled, vaguely bioturbated aspect. In terms of colour, component, and texture, unit is truely transitional between N and M1.

28.7 – 31.2 M1 (Amco Shale). *Marl.*

Typical, medium grey, fairly competent, limy unit: more of a marl than a shale. Crinoid ossicles occur, scattered sporadically throughout. A very vaguely bioturbated texture is developed in part. Marl is pyritic, with small marcassite nodules occassionally developed.

31.2 – 32.5 M3 (Lower Amco). *Fossiliferous limestone.*

Wispily argillaceous, light greyish brown, fossiliferous limestone. Uppermost 30 cm hosts thick brachiopods, and marcassite stained, blue – grey lithoclasts. For remainder 2 – 5 cm bulbous stromatoporoids predominate, draped by, and distorting argillaceous wisps. Basal contact with Watt Mountain is very sharp.

32.5 - 58.8 WATT MOUNTAIN FORMATION.

32.5 - 41.0 Blotchy Member. *Limestone.*

Typical sequence of quite dense, light greenish grey, finely crystalline limestones. The Amphipora Marker Bed occurs 38.1 - 38.4, and hosts bulbous stromatoporoids, as well as amphipora. Fossils are partially leached, to give fossil moldic vugginess in part. This marker bed seperates an upper blotchy member, which has a more laminated, fissile nature, with fine ,elongate reduction mottles, from a lower blotchy member, which is more competent, with characteristic coarse reduction mottles. Fine, anastamosing, horsetailing wisps are locally developed.

Charophyta rich, shaly - gritty beds occur throughout -especially in the upper member. These are generally very thin, except @ 36.4 - 36.7, a very fissile green shale.

41.0 - 43.0 Gritty Member. *Argillaceous limestone.*

Quite poorly developed. The overlying "blotchy" limestones grade transitionally down into a greener, more marly limestone, with characteristic small, subrounded intraclasts, which seem to coarsen downward and @ 41.3 - 41.45 give way to a soft, green and brown shale horizon. The remainder of the sequence is, for the most part, very much like the overlying blotchy material. However 42.4 - 43.0 unit again begins the gritty marl/shale interbeds characteristic of this unit.

43.0 - 44.2 Upper Micrite. *Micritic limestone.*

Again, rather poorly, and thinly developed. However unit is typical fine, dense limestone, with very abundant motheaten style vugs.

44.2 - 46.0 Upper Shale. *Limy and dolomitic shales and marls.*

Extremely heterogeneous sequence. Initially a finely reduction mottled marl, with very abundant charophyta, followed by a wispily argillaceous (horsetailing) micritic? unit, followed by a dull/earthy, finely mottled/marbled, dolomitic marl. This, in turn, is followed by another

wispy/shaly bed, with a deformed (soft sediment) swirling texture in part. The four units so described each comprise approx. 25% of the interval.

46.0 – 48.8 Lower Micrite. *Micritic limestone.*

Quite typical, dense, creamy beige, micritic, stylolitic limestone, with a fine, motheaten style of vugginess.

48.8 – 51.8 Silty Dolomite. *Fine grained dolomite.*

Dull, earthy, light creamy brown, finely silty textured dolomite. Extremely porous in part – denser, finely laminated in part.

51.8 – 57.9 Lower Shale. *Limy and dolomitic shales and marls.*

Dolomitic 51.8 – 54.3, limy 54.3 – 56.4. Typical heterogeneous sequence of fissile green shales. Light, creamy white, almost chalky textured limestones, and heterogeneous wispy mixtures of the two.

57.9 – 58.5 Basal Marine? *Dense dolomite.*

Very difficult to identify here, as interval is dolomitized, and recovery from 55.2 – 59.1 is very poor (less than 1.2 m) and footages are doubtful.

58.5 – 63.1 B BIOSTROMAL "FORMATION". *Dolomite.*

Fairly typical, medium to light brown, wispily argillaceous, dense dolomite. There is a vaguely bioturbated aspect throughout especially upper half. Coralline debris is scattered throughout, but is especially abundant in central portion (59.4 – 60.7). From 60.7m on unit is somewhat lighter, greyer than usual, and has more of a sandy texture, as opposed to the more usual, dense, finely crystalline texture. Unit is patchily, partially limy which is again, somewhat unusual.

63.1 – 70.1 BUFFALO RIVER "FORMATION".

63.1 – 64.0 G1 Shale.*Dolomitic shale.*

Med grey, fissile, dolomitic, pyritic shale. (Weathered to fine shaly fragments.) Lowermost 15 cm is cosiderably more competent more of

a dolomitic marl – with a marbly, G3-like, texture.

64.0 – 64.3 G B Marker Bed. *Dolomite.*

Typical. Totally identical to overlying B Bio. Vaguely bioturbated, finely wispy, finely silty, med. brown in colour. Upper half is dominated by long, elongate blebs of overlying G1 material.

64.3 – 66.3 G1 Shale. *Dolomitic shale.*

Extremely fissile (weathered) soft, pyritic shale green-grey in colour – quite typical, except that interval is dolomitic. There is evidence of veining by white dolspar here however weathered nature of core makes description difficult.

66.3 – 66.7 G2 *Nodular argillaceous dolomite.*

In spite of dolomitization lighter grey 'micritic' nodules are clearly identifiable, within darker, more wispy matrix. Dolomitization has rendered a "sandy" texture throughout.

66.7 – 67.1 G2 *Nodular argillaceous dolomite.*

Very similar to G2 above, but containing scattered, lacy, coralline debris (toward base fossils are 100% replaced by white dolspar, and impossible to identify).

67.1 – 67.4 G1 Shale. *Dolomitic shale.*

Short interval – as described previously – still dolomitic.

67.4 – 69.2 G2 *Nodular argillaceous dolomite.*

Very similar to (fossiliferous) unit described previously. Dolomitized to an overall sandy texture, unit has a ghosted nodular texture throughout, within a wispier matrix. Marcassite impregnation is common, as are scattered, lacy corals.

69.2 – 70.1 G5? *Dolomite.*

A cleaner, more distinctly sandy textured unit – very E like, but denser, and with a distinct grey cast to it. Finely abraded fossil debris can be discerned, in part.

70.1 – 91.4 PINE POINT FORMATION.

70.1 – 78.9 K E Facies. *Dolomite.*

Presqu'ilized to typical rhombic dolomite, such that a pitted, sponge like texture is developed throughout this med light brown dolomite. The basal contact is very transitional into 'normal' E facies.

78.9 – 91.4 E Facies. *Dolomite.*

Typical, sandy, extremely porous dolomite. Calcite flooded in part to give blue grey 'spots'.

E.O.H. @ 91.4 m

Cominco D.D.H. 4320

0 – 12.2 Casing/Overburden.

12.2 – 42.1 SLAVE POINT FORMATION.

12.2 – 27.4 O Facies. *Variable sequence of limestone.*

27.4 – 38.1 N Facies. *Variable sequence of limestone and dolomite.*

38.1 – 42.1 Amco Member.

No Upper Amco recovered here.

38.1 – 41.2 M1 (Amco Shale). *Marl.*

Blue grey, limy shale/marl. Quite competent. Thick and well developed here, and apparently overlain by Spitfire textured N Facies.

41.2 – 42.1 M3 (Lower Amco). *Fossiliferous limestone.*

Light greyish – brown overall. Pinkish bulbous stromatoporoids float in a wispy matrix.

42.1 – 66.8 WATT MOUNTAIN FORMATION.

42.1 – 50.9? Blotchy Member. *Limestone and dolomite.*

Quite typical sequence of fine to coarsely reduction mottled limestones and dolomites – all finely crystalline – dense. Unit is limy to 46.6 m, and is dominated by a fine reduction mottling and a fine laminar texture. 46.6 – 47.1 Amphipora Marker Bed. From 47.1 m on unit is coarsely reduction mottled, and dolomitic.

N.B.48.5 – 52.1 Recovery is extremely poor (1.0 m), and it is within this zone that the Gritty Member and Upper Micrite appear to have been lost.

50.9 – 52.4 Upper Micrite. *Micritic limestone.*

Remnant? Pieces of dense, finely crystalline limestone recovered.

52.4 – 54.3 Upper Shale. *Marl / limy shale.*

52.4 – 53.6 Green, richly argillaceous, limy marl, with abundant charophyta (reminiscent of Gritty). 53.6 – 54.3 Fissile, dolomitic marl, approaching a shale in character.

54.3 – 56.4 Lower Micrite. *Micritic limestone.*

Typical, light cream, fine, micritic? limestone. Abundantly stylolitic. Fairly fine, motheaten style vugginess developed throughout.

56.4 – 60.4 Silty Dolomite Member. *Fine grained dolomite.*

Typical, finely laminated, extremely porous, finely silty textured dolomite. Light creamy coffee in colour.

60.4 – 64.3? Lower Shale Member. *Limy and dolomitic shales and marls.*

Heterogeneous sequence of green shales, marls, and marbled textured dull, chalky limestones, predominantly light cream in colour. Green shales predominate, and are extremely fissile. Unit is dolomitic up to 63.4 m, and from 63.7 m on.

64.3 – 66.8 Basal Marine Member. *Dolomite.*

Initially medium grey in colour, unit darkens to a medium dark brown toward base. Dolomitization has caused a speckled/sandy texture throughout. Entire unit shows characteristic white dolspar blebs and speckles (burrowing?).

66.8 – 70.8 B BIOSTROMAL "FORMATION". *Dolomite.*

Med to light brown, fairly dense, finely crystalline to finely silty textured dolomite. Finely, and faintly, wispily argillaceous. Unit again seems to darken with depth. Macro-fossils are absent – however the overall disturbed texture is suggestive of burrowing.

70.8 – 81.1 BUFFALO RIVER "FORMATION".

70.8 – 72.4 G1 Shale. *Dolomitic shale.*

Fissile, medium green grey, pyritic, dolomitic shale.

72.4 – 72.9 G B Marker Bed. *Dolomite.*

Identical to overlying B Biostromal.

72.9 – 75.0? G1 *Dolomitic shale,* as above.

75.0 – 76.3? G2 *Nodular argillaceous dolomite?*

76.3 – 80.2??81.1? G5? Core recovery is extremely poor here. There is probable karst involvement. Pieces of a med/light grey, sandy dolomite recovered. There is evidence of a fine, dolspar healed, brecciation here.

81.1 – 91.4 Pine Point Formation *continued poor core recovery*

81.1 – 84.7 Karsted KBRS?????? *Argillaceous dolomite.*
Possible SRF growth, with chocolate brown I/S.

84.7 – 91.4 (K)E Facies. *Dolomite.*

E.O.H. @ 91.4 m

Cominco D.D.H. 4319

0 – 12.2 Casing/Overburden.

12.2 – 29.3 SLAVE POINT FORMATION.

12.2 – 25.0 N Facies. *Variable sequence of limestone.*

25.0 – 29.3 Amco Interval.

25.0 – 25.5 M2 (Upper Amco). *Fossiliferous limestone.*

Light/med grey, argillaceous limestone, hosting relatively rare, pinkish-cream, stromatoporoid fragments.

25.5 – 27.9 M1 (Amco Shale). *Marl.*

Med grey, fairly uniform, competent limy shale/marl. Rare, scattered crinoid ossicles (pinkish), in upper 30 cm especially.

27.9 – 29.3 M3 (Lower Amco). *Fossiliferous limestone.*

A somewhat transitional unit between M1 and upper Watt Mountain. A wispily argillaceous, medium light grey limestone, with a distinct, fine, intraclastic texture (lighter grey lithoclasts) and thin shelled brachiopod debris. Unit is less intraclastic toward base – more uniform, with rare stromatoporoid debris.

29.3 – 54.6 WATT MOUNTAIN FORMATION.

29.3 – 36.6 Blotchy Member. *Limestone.*

Fairly typical, heterogeneous sequence of limestones and lesser dolomites, with a characteristic blotchy texture – fine and elongate in upper half, coarse and camouflage like in lower half – seperated by the Amphipora Marker Bed (33.8 – 34.1). The Marker Bed here is markedly vuggy, and may contain larger (leached) stromatoporoid fragments.

36.6 – 37.5 Gritty Member. *Argillaceous limestone.*

Upper half reduction mottled in a transitional manner from overlying

Blotchy. However unit is distinctly greener in colour, more argillaceous, and rapidly becomes marl like. Lower half has typical, intraclastic, gritty texture. Charophyta may be present in part.

37.5 – 39.9 Upper Micrite. *Micritic limestone.*

(For the most part, but hosting some gritty material centrally.) Predominantly a light creamy beige, micritic? limestone. Lower half is characteristically vuggy: upper half (to 38.4 m) is somewhat intraclastic. 38.4 – 38.7 small shaly interval – flaser textured.

N.B. Gritty Member may extend to 38.7 m?

39.9 – 42.1 Upper Shale. *Limy and dolomitic shales and marls.*

Upper half reduction mottled, charophyta rich shale/marl. Lower half is more distinctly shaly – fissile. The shale portion here as a much darker, blue – green colour, and is dolomitic. Contact occurs 41.2 – 41.5 – difficult to judge.

42.1 – 44.8 Lower Micrite. *Micritic limestone.*

Typical, extremely vuggy, light creamy grey, micritic limestone

N.B. Recovery at this point becomes very poor, making contacts approximate.

44.8 – 47.2? Silty Dolomite. *Fine grained dolomite.*

Typical, finely bedded, porous, coffee coloured dolomite. Recovery extremely poor.

47.2 – 52.1 Lower Shale Member. *Limy and dolomitic shales and marls.*

Limy from approx 50.3 m on, upper half is dolomitic. Fairly typical heterogeneous sequence of shales, marls, and flaser – bedded, cream, limestones.

52.1 – 54.6 Basal Marine Member. *Dolomite.*

Dolomitized throughout; typical to sandy textured, medium to grey – brown dolomite, with characteristic white dolspar speckling. Unit becomes darker brown,wispier, with depth. Basal contact extremely difficult to pick possibly higher? @ 54.3 m???

54.6 - 57.9 B BIOSTROMAL "FORMATION".

Fossiliferous dolomite.

Med brown, wispily argillaceous, dolomite, with fairly abundant, scattered fossil debris (digitate stromatoporoids? corals? brachiopods). Wisps appear to splay about fragments.

N.B. Recovery rather poor. Unit appears to be involved in underlying karst.

57.9 - ? BUFFALO RIVER "FORMATION".

N.B.Core recovery here is *extremely* poor. From 58.2 - 72.2, *less than 1.5 m* recovered. Inclined bedding suggests collapse/karsting.

To 60.1 m Fissile shale, and G3 like material.

To 63.1 m Mixture, Buffalo River and Pine Point Formation

To 66.1 m No Recovery.

To 69.2 m B Reef Substrate.

To 72.2 m BRS transitional into E Facies.

From 72.2 m on, K E Facies.

E.O.H. @ 91.4 m

Cominco D.D.H. 4318

0 – 9.8 Casing/Overburden.

9.8 – (24.8) SLAVE POINT FORMATION.

9.8 – 20.7 N Facies. *Variable sequence of limestone and dolomite.*

20.7 – 24.8 Amco Interval.

20.7 – 24.1 M1 (Amco Shale). *Marl.*

Typical, dense, medium grey marl. Quite unifor m Faint, fine, bioturbation mottles. Rare, scattered, crinoidal debris. (Thin brachiopods and light grey nodules @ contact – transitional.)

24.1 – (24.8) M3 Lower Amco. *Fossiliferous limestone.*

(Uppermost 60 cm only, available). Light greyish brown, wispily argillaceous, quite densely fossiliferous limestone. Intraclastic, especially toward top?,with abundant digitate and/or bulbous stromatoporoids, with oncolitic rims.

N.B. Interval 24.7 - 30.8 missing / unavailable.

(24.8) – 48.8 WATT MOUNTAIN FORMATION.

24.8 – 32.6 Blotchy Member. *Dolomite.*

(Uppermost 6.0 m missing). Typical, coarsely reduction mottled, finely crystalline dolomite. Becomes marginally greener – shalier – toward base.

32.6 – 34.1 Gritty Member. *Argillaceous limestone.*

Highly variable sequence of greenish marls (hosting charophyta), clean intraclastic limestones, and flaser textured limestones with horsetailing green shale wisps. However, 'gritty' textured, intraclastic material predominates – either as a clean limestone, or transitional into a marl.

34.1 – 35.4 Upper Micrite. *Micritic limestone.*

Typical, clean, dense, creamy white limestone, with abundant cellular style vugs of 2-3 mm avg. diameter, which gives the core a tendency to break.

35.4 - 37.8 Upper Shale. *Limy and dolomitic shales and marls.*

Material very similar to Gritty Member sandwiches a bright green dolomitic shale (36.3 - 37.2). The "gritty" beds are dull greenish marls for the most part, reduction mottled, and hosting charophyta. The shale, itself, is extremely brittle and fissile

37.8 - 39.6 Lower Micrite. *Micritic limestone.*

Clean, stylolitic, dense, finely crystalline, creamy white limestone. Well developed motheaten style vugginess.

39.6 - 41.8 Silty Dolomite Member. *Fine grained dolomite.*

Quite typical, very finely bedded, very finely silty textured dolomite. Very porous - occassionally enlarged to give a fine, irregular vugginess.

41.8 - 47.9 Lower Shale Member. *Limy and dolomitic shales and marls.*

(Dolomitic to approximately 45.7 m) Heterogeneous sequence of bright green, brittle, fissile shales; clean, creamy greyish-white limestones; and transitional flaser bedded sequences. The cleaner limestones appear to be finely grainy - possibly intraclastic?? There is minor nodular gypsum @ 45.1 m, associated with a green marl.

47.9 - 48.8 Basal Marine Member. *Dolomite.*

Somewhat uncharacteristically dolomitized - and possibly bitumen impregnated and speckled. Characteristic white dolspar blebs (after burrows?) are well developed throughout.

N.B. There is a brownish/greenish/bluish clay band (5 cm) @48.8 m - apparently pyritic.

48.8 - 52.1 B BIOSTROMAL "FORMATION". *Fossiliferous dolomite.*

Richly fossiliferous unit - dolomitic with abundant chocolate brown, argillaceous wisps, splaying about fossil fragments. There are, however,

somewhat cleaner intervals with a somewhat unusual bluish grey colour. Lacy coralline debris predominates, with tabular stromatoporoids, and medium shelled brachiopods also fairly abundant. Basal contact is extremely sharp.

52.1 – 56.1 BUFFALO RIVER "FORMATION".

52.1 – 52.7 G1 Shale. *Dolomitic shale.*

Soft, fissile, dolomitic, greenish – grey in colour.

52.7 – 53.3 G B Marker Bed. *Dolomite.*

Small unit, virtually identical to overlying B Bio. Upper half is darker brown, lower half has a cleaner, more bluish – grey hue.

53.3 – 54.9 G1 Shale. *Dolomitic shale* as above.

54.1 – 56.1 G5.*Sandy dolomite.*

Fine, medium grey, dense, sandy dolomite – minor coralline debris in uppermost 30 cm

N.B. Recovery is poor here, and unit is quite heavily veined by white dolspar. Glassy bitumen also occurs, associated with veinlets, or fossil moldic vugginess (very minor).

56.1 – 61.0 SULPHUR POINT FORMATION.

56.1 – 61.0 K D2 Facies. *Dolomite.*

For the most part a stomatoporoid boundstone. Quite intensely Presqu'ilized to produce a lattice-work like vugginess – often bitumen filled. There is every indication, also, of strong solution activity here, with abundant white dolspar, and blue dolspar increasing with depth, as unit grades into .....

61.0 – 91.4 PINE POINT FORMATION.

61.0 – 66.1 K B Reef Substrate -- K B – E Facies. *Argillaceous*

dolomite.

Heavily karsted and replaced. Abundant blue dolspar. Original rock richly fossiliferous (massive stromatoporoids?), with abundant dk brown argillaceous/carbonaceous wisps. Abundant internal sediment – especially 64.0 – 64.6. Unit grades transitionally downward into less fossiliferous B – E facies.

66.1 – 80.8 K E – B Facies. *Dolomite.*

The Presqu'ile would appear to be anomalously thick here?? producing a fairly clean, rhombic dolomite, light to medium brown in colour. Fairly abundant, stringer like white dolspar. Scattered macrofossils occur rarely throughout.

80.8 – 91.4 B – E Facies. *Wispy dolomite.*

Approaching B Marine – wispily argillaceous, with relatively rare crinoidal and brachiopod debris. Footage markers are difficult to read, however this unit has suffered more from dolomitization than usual, such that the upper half is essentially a sucrosic dolomite, resulting in an E'ish look. This effect fades with depth, resulting in a more normal BMD. The last 1.2 m is preserved as limestone.

E.O.H. @ 91.4 m

Cominco D.D.H. 4317

0 – 10.4 Casing/Overburden.

10.4 – 26.4 SLAVE POINT FORMATION.

10.4 – 22.6 N Facies. *Variable sequence of limestones.*

22.6 – 26.4 Amco Member.

22.6 – 25.0 M1 (Amco Shale). *Marl.*

Typical medium grey, dense, earthy, marl. Quite uniform, rather featureless. Uppermost 30 cm has unusual patchy/blotchy texture possibly after burrows .

25.0 – 26.4 M3 (Lower Amco). *Fossiliferous limestone.*

Typical, fossiliferous,wispily argillaceous limestone. Lithoclastic toward top clasts are enhanced by blue grey staining. Contact with overlying shale is of usual transitional nature. Thin shelled brachiopod debris is quite abundant.

26.4 – 48.8 WATT MOUNTAIN FORMATION.

26.4 – 34.1 Blotchy Member. *Limestone.*

26.4 – 30.8 Characteristic fine reduction mottling, elongate parallel to bedding which is also fine, and well developed. A fine, sponge – like vugginess is developed sporadically, associated with bedding. Charophyta – rich beds occur occasionally, as do some finely gritty beds

30.8 – 31.1 Amphipora Marker Bed – light coffee-brown, fairly dense limestone, with abundant, fine, faintly purplish, amphipora. Very faintly wispy.

Fine crystalline, dense, coarsely reduction mottled sequence of limestone. Possibly partially dolomitized.

34.1 – 35.8 Gritty Member. *Argillaceous limestone.*

Distinctly cleaner than usual – however the characteristic intraclastic 'gritty' texture is extremely well developed here – and apparently fines downward. The upper and lowermost 4 cm is distinctly green in colour – wispy.

35.8 – 36.9 Upper Micrite. *Micritic limestone.*

Clean, creamy grey, fine, dense limestone. Very faintly flaser-bedded in part. Cellular-style vugginess rather poorly developed here.

36.9 – 39.0 Upper Shale. *Limy and dolomitic shales and marls.*

36.9 – 37.8 Typical dull, earthy, reduction mottled, green shale, with abundant charophyta. Remainder of sequence is typical blue – green shale, becoming 'marly' toward base. 37.8 – 39.0 is dolomitic, upper portion is limy.

39.0 – 40.5 Lower Micrite. *Micritic limestone.*

Typical, dense, finely crystalline limestone. Stylolitic in part – a 'motheaten style' vugginess is also developed in part.

40.5 – 43.6? Silty Dolomite. *Fine grained dolomite.*

Finely bedded, finely silty textured dolomite. Overall, porous in nature. Recovery is characteristically poor.

43.6 – 47.4 Lower Shale Member. *Limy and dolomitic shales and marls.*

Uppermost 1.5 m dolomitic – remainder limy. Fairly typical heterogeneous sequence of green shales, marls, and cleaner limestones; frequently flaser bedded, intraclastic in part. This interval is perhaps a little cleaner, less shaly than usual.

47.4 – 48.8 Basal Marine Member. *Limestone.*

Light, pinkish-brown, dense, fine limestone, riddled with green clay filled voids – worm like. (These are possibly burrows which give the usual "dolspar blebs"??) There is some fine shelly debris – possibly ostracods @ 47.6 m Once again, recovery is rather poor here.

48.8 – 49.1 A thick, limy, greenish brown clay seam is developed here, containing small, subangular fragments – possible disconfomity????

49.1 – 53.6 B BIOSTROMAL "FORMATION". *Fossiliferous dolomite.*

("Atypical", near pinch-out, base somewhat arbitrary?) This unit is typical of B Biostromal as it nears the pinch out. Densely fossiliferous, with abundant corals, massive and pancake stromatoporoids, and lesser thick shelled brachiopods Fossils are self supportive, almost reefal in aspect, and are pale pinkish cream in colour Unit is quite clean, although green clay wisps are fairly abundant in upper-half. Bitumen impregnation between grains, and along wisps is common, and gives an overall greyish hue to the "matrix". From 53.0 m on, fossils become less densely packed, and a grey, sandy, G5-like matrix becomes more prevalent. However fossils are still abundant (corals especially) and comprise approx. 30% of sequence to 53.6 m At this point fossils vanish abruptly.

53.6 - 57.5 BUFFALO RIVER "FORMATION".

53.6 - 54.3 *Argillaceous dolomite.*

Dark grey, sandy, finely bedded dolomite.

54.3 - 55.2 G1 Shale? *Dolomitic.*

(Initially?) - now partially degraded to soft clay. However in the uppermost 30 cm a G3 texture is clearly preserved.

55.2 - 57.5 A G5, sandy dolomite predominates here however there is some karst involvement, producing a breccia, which is in part healed by remobilized G3?

57.5 - 61.6? SULPHUR POINT FORMATION.

57.5 - 60.7 K D2 Facies? *Karsted and replaced.*

Bands of I/S are growing SRF's (dark and light grey repectively), with white dolspar veining and replacement. A ghost lattice work like vugginess suggests a D2 affinity.

60.6 - 61.6 K SRF. Clean, light creamy beige, sub - rounded forms. Fairly typical K C Facies?

61.6 – 91.4 PINE POINT FORMATION.

61.6 – 71.9 K BRS – (K D2) Transitional. *Fossiliferous dolomite.*

Typical, problematical interval. "A little on the brown side for D2 – a little too clean for BRS." Massive stromatoporoids are present throughout – but this is in no way a boundstone. Fossils present here seem more akin to BRS?

As the Presqu'ile dies out, this unit grades transitionally downward into distinctly B – E Facies suggestive of a Pine Point affinity?

71.9–78.0 B – E Facies. *Wispy dolomite.*

Wispily argillaceous, sandy textured dolomite. Crinoidal and brachiopod debris locally abundant, within more richly argillaceous beds.

78.0 – 91.4 E(– B) Facies. *Dolomite.*

Fairly clean, sandy, sucrosic dolomite. Possibly a little darker than usual – B'ish.

E.O.H. @ 91.4 m

Cominco D.D.H. 4316

0 – 10.4 Casing/Overburden.

10.4 – 20.4 SLAVE POINT FORMATION.

10.4 – 16.9 N Facies. *Variable sequence of limestones.*

16.9 – 20.4 Amco Member.

16.9 – 19.2 M1 (Amco Shale). *Marl.*

Med grey, limy shale/marl.

19.2 – 20.4 M3 (Lower Amco). *Fossiliferous limestone.*

Quite abundantly wispy, fossiliferous limestone. Coarsely intraclastic toward the top.

20.4 – 41.8 WATT MOUNTAIN FORMATION.

20.4 – 27.7 Blotchy Member. *Limestone.*

20.4 – 25.0 Upper Blotchy – fairly typical, medium light, brownish-grey, finely bedded, finely intraclastic, finely reduction mottled limestone. Small interbeds of a somewhat greener hue, hosting charophyta, are developed. Unit is finely vuggy in part.

25.0 – 25.3 Amphipora Marker Bed.

25.3 – 27.7 Lower Blotchy – quite dense, finely crystalline, coarsely reduction mottled. Becomes somewhat marly toward base, slightly greenish.

27.7 – 29.3 Gritty Member. *(Argillaceous) limestone.*

Somewhat cleaner than usual, highly intraclastic limestone. Very distinctive. Minor reduction mottling toward top – which is also greener unit 'cleans-up' with depth.

29.3 – 31.1 Upper Micrite. *Micritic limestone.*

Clean, stylolitic, cellular vuggy, fine dense limestone.

31.1 – 32.6 Upper Shale. *Limy shales and marls.*

First 90 cm greenish - grey, coarsely reduction mottled, marly limestone. (Last 30 cm cleaner, more intraclastic - somewhat similar to gritty member.) Last 60 cm more typical, bluish green marl blocky, approaching a shale in part.

32.6 - 34.1 Lower Micrite. *Micritic limestone.*

Classic example of a clean, extremely vuggy, fine limestone with abundant, fine needle-like vugs no doubt after gypsum crystals.

34.1 - 37.2 Silty Dolomite Member. *Fine grained dolomite.*

Typical, extremely porous (sponge-like), finely bedded, silty textured dolomite.

Basal contact somewhat uncertain - recovery 35.7 - 38.7 very poor.

37.2 - 41.8 Lower Shale. *Limy and dolomitic shales and marls.*

Typical heterogeneous sequence of blue - green shales, marls, and cream and green 'marbled' beds. Upper half is dolomitic, lower half limestone.

41.8 - 46.0 B BIOSTROMAL "FORMATION". *Fossiliferous dolomite.*

Extremely well developed "reefal" BBio. Massive stromatoporoids predominate, especially in lower half, encrusting Thamnopora corals. Upper half hosts more abundant corals, and is perhaps more rubbly looking? Unit is limy to 44.2 m (equivalent to "upper half"), and it is here that purplish - grey bitumen impregnation and staining is strongest. (Could this reflect an association with an unconformity?? cf. D2 Limestone @ unconformity.) Where massive stromatoporoids predominate, unit is much cleaner, creamy - beige in colour.

46.0 - 48.8 Karsted/Brecciated BUFFALO RIVER "FORMATION".

Buffalo River material is fairly competent here. Fragments are apparently, and for the most part, G3 and G5 derived. Fragments are healed by white dolspar Minor I/S development toward base. (There is some mixing with

Presqu'ilized material here.)

48.8 - 61.6 SULPHUR POINT FORMATION.

48.8 - 54.0 K D2 Facies. *Stromatoporoidal dolomite.*

(Upper contact is karst involved, but this extends <1.0 m)

A fairly classic KD2 is developed here.

54.0 - 57.0 K SRF/C Facies. *Sandy dolomite.*

Clean, fairly typical.

57.0 - 61.6 Difficult to identify any large fossil fragments here. This is apparently the more bioclastic version of D2, with numerous K SRF interbeds (of more C like material). The uppermost D2 (proper) contains massive stromatoporoids, and some beautiful stachyoides gravel beds. However this uppermost zone is heavily replaced by white dolspar - and there is patchy blue grey marcassite staining.

61.6 - 76.2 PINE POINT FORMATION.

61.6 - 76.2 E Facies. *Sandy dolomite.*

Presqu'ilized to approximately 64.0 m From then on this is a quite typical, clean, porous, sandy dolomite, with rare, diffuse, argillaceous wisps.

E.O.H. @ 76.2 m

Cominco D.D.H. 4315

0 – 9.8 Casing/Overburden

9.8 – 22.6 SLAVE POINT FORMATION.

9.8 – 18.0 N Facies. *Variable sequence of limestone and dolomite.*

18.0 – 22.6 Amco Member.

18.0 – 18.3 M2 (Upper Amco). *Fossiliferous limestone.*

18.3 – 21.3 M1 (Amco Shale). *Marl.*

21.3 – 22.6 M3 (Lower Amco).

Fossiliferous limestone.

22.6 – 42.7 WATT MOUNTAIN FORMATION.

22.6 – 29.6 Blotchy Member. *Limestone>*

Quite typical – although the Amphipora Marker Bed (26.8–27.1) is somewhat poorly developed being not nearly so densely fossiliferous. Otherwise unit is entirely typical, and is limestone throughout.

29.6 – 31.1 Gritty Member. *Argillaceous limestone.*

Quite typical, strongly intraclastic bed. More richly argillaceous toward top (greener in colour), becoming quite clean toward base.

31.1 – 32.6 Upper Micrite. *Micritic limestone.*

Extremely well developed, clean, stylolitic, micrite.

32.6 – 34.1 Upper Shale. *Limy and dolomitic shales and marls.*

A more or less typical, bluish green,marly, dolomitic shale is sandwiched by cleaner, gritty textured in part, wispy limestones. Last 30–60 cm is quite strongly reduction mottled.

34.1 – 35.7 Lower Micrite. *Micritic limestone.*

Quite typical, much like Upper Micrite.

35.7 – 38.7 Silty Dolomite Member. Again a typical, finely bedded, porous, light coffee-brown dolomite.

38.7 – 42.7 Lower Shale. *Limy and dolomitic shales and marls.* Dolomitic to approximately 41.2 m Quite typical heterogeneous sequence of blue-green shales, marls, and light, creamy (marbled) limestones and dolomites.

42.7 – 47.2 B BIOSTROMAL "FORMATION". *Limestone throughout.* Richly fossiliferous unit – abundant masive and tabular stroms, and thamnopora corals. For the most part fossils are entirely self supportive however for most of the unit green clay seams and wisps are pervasive. Massive stromatoporoids are more abundant toward base.

47.2 – 50.6? BUFFALO RIVER "FORMATION". *Wispy dolomite.* Thick, uniform sequence of G5, 'sandy' textured dolomite. Distinctive 'Buffalo River grey' colour developed throughout. Extremely well developed N.B. Possibly an extra 60 cms of G5 may have been jumbled out of place into underlying unit.

50.6? – 64.6? SULPHUR POINT FORMATION. *Dolomite.* Quite brownish – dirty looking. Interbeds of K SRF in a strongly Presqu'ilized D2 (at the top) give way (around 57.9 m) to more of a K SRF, less D2. (Never really good)

64.6? – 76.2 PINE POINT FORMATION. *Dolomite.* E Facies only recovered (Presqu'ilized to approximately 67.0 m) This is typical E.

E.O.H. @ 76.2 m

Cominco D.D.H. 4314

0 – 9.8 Casing/Overburden.

9.8 – 28.0 SLAVE POINT FORMATION.

9.8 – 23.5 N Facies. *Variable sequence of limestone and dolomite.*

23.5 – 28.0 Amco Member.

23.5 – 23.8 M2 (Upper Amco)? *Limestone.*

Essentially a transitional zone from N into M1.

23.8 – 26.5 M1 (Amco Shale). *Marl.*

26.5 – 28.0 M3 (Lower Amco). *Fossiliferous limestone.*

Not quite so richly fossiliferous as usual. Distinctly, and coarsely, intraclastic in upper 30–60 cm – within 'transition zone'.

28.0 – 48.3 WATT MOUNTAIN FORMATION.

28.0 – 35.4 Blotchy Member. *Limestone.*

Quite typical, extremely well developed. Amphipora Marker Bed (32.3–32.6) seperates an upper, more finely bedded, somewhat fissile and finely vuggy limestone, from the lower, denser, more massive limestone.

35.4 – 36.9 Gritty Member. *Argillaceous limestone.*

Quite clean, and very finely intraclastic somewhat atypical.

36.9 – 38.4 Upper Micrite. *Micritic limeston>*

Quite well developed, light cream, finely vuggy micrite. Finely stylolitic – stylolites occassionally lined by green clay.

38.4 – 40.2 Upper Shale. *Limy and dolomitic shales and marls.*

Again, fairly typical, blue-green, dolomitic shale, sandwiched by more transitional, reduction mottled marls, and intraclastic, gritty beds.

40.2 – 41.9 Lower Micrite. *Micritic limeston>*

Fairly dense, light cream, finely crystalline limestone.

41.9 – 45.0 Silty Dolomite Member. *Fine grained dolomite.*

Absolutely typical, light coffee-brown, finely bedded, porous dolomite.

45.0 – 48.3 Lower Shale. *Limy and dolomitic shales and marls.*

(Dolomitic to approximately 46.3 m) Typical green shales, marls, and flaser bedded, wispy carbonate.

48.3 – 51.2 B BIOSTROMAL "FORMATION". *Fossiliferous limestone / dolomite.*

Upper half limestone, lower half dolomite. Typical, massively fossiliferous B Bio. Lowermost 30 cm is dominated by a single massive strom, the remainder contains thamnoporoids, thick brachs and tabular stroms. Fossils are densely packed, self-supportive for the most part. Occassionally a coarse, bioclastic matrix is developed.

N.B. Corals "lie" horizontally.

51.2 – 52.4 BUFFALO RIVER "FORMATION". *Wispy dolomite.*

G5, sandy textured dolomite – quite typical. Medium grey in colour. The basal contact is filled, and obscured, by glassy, black, bitumen The upper contact is sharp, and extremely well defined.

52.4 – ? SULPHUR POINT FORMATION.

52.4 – 65.2 K D2 Facies. *Fossiliferous dolomite.*

There is a very strong, and sharp, crystallinity break here. Massive stromatoporoids yield a strong, lattice-work like vugginess, vugs lined by a glassy, black bitumen. This is 'good' D2 Boundstone to 57.0 m

57.0 – 57.9 Quite strange bed almost looks like a K J1??????

Blue-grey, distinctly laminated, with white dolspar blebs.

57.9 – 60.1 Stachyoides gravel. Matrix is blue-grey in colour, marcassite stained.

60.1 – 65.2 D2 Rudstone.

65.2 – / K SRF. Possibly dark er than usual.

Hole continues to E shale marker – not logged at this time.

E.O.H: @206.4 m

Cominco D.D.H. 4313

0 – 10.4 Casing/Overburden.

10.4 – 27.4 SLAVE POINT FORMATION.

10.4 – 22.3 N Facies. *Variable sequence of limestone and dolomite.*

22.3 – 27.4 Amco Member.

22.3 – 22.7 (Upper Amco). *Fossiliferous limestone.*

22.7 – 25.9 M1 (Amco Shale). *Marl.*

25.9 – 27.4 M3 (Lower Amco). *Fossiliferous limestone.*

Less fossiliferous than usual. Wispily argillaceous. Contact with M1 somewhat transitional. Large crinoid ossicles abundant, thick-shelled brachs, dark grey rimmed lithoclasts.

27.4 – 47.2 WATT MOUNTAIN FORMATION.

27.4 – 34.1 Blotchy Member. *Limestone.*

Hosts well developed Amphipora Marker Bed (30.8 – 31.1). Unit is dolomitized from approximately 30.5 m on. Otherwise quite typical.

34.1 – 36.0 Gritty Member. *Argillaceous limestone.*

Rather thick, quite clean, intraclastic limestone. Only uppermost 30 cm is truly green in colour, and is argillaceous. Remainder is faintly wispy, but on the whole very clean.

36.0 – 37.2 Upper Micrite. *Micritic limestone.*

Rather thin, stylolitic, clean, almost white limestone.

37.2 – 38.7 Upper Shale. *Limy and dolomitic shales and marls.*

Quite typical, blue-green shale, approaching a marl (dolomitic), beneath more intraclastic, limy material much like the Gritty Member.

38.7 – 40.2 Lower Micrite. *Micritic limestone.*

More or less not recovered.

40.2 – 43.3 Silty Dolomite Member. *Fine grained dolomite.*

Very poor recovery, but quite typical nonetheless.

43.3 – 47.2 Lower Shale. *Limy and dolomitic shales and marls.*

Quite normal to 45.4 m, but from then on unit is coarsely dolomitized – almost Presqu'ilized?? to give a 'salt and pepper' texture.

47.2 – 47.9 B BIOSTROMAL "FORMATION". *Fossiliferous dolomite.*

Densely packed thamnoporoid corals in a brown clay 'matrix', together with indeterminate fossils (massive stroms?). Massively recrystallized.

47.9 – 48.5 BUFFALO RIVER "FORMATION". *Wispy dolomite.*

G5?? Dense, medium grey, sandy dolomite. Abundant replacement by stringers of white dolspar.

48.5 – ? SULPHUR POINT FORMATION.

48.5 – ? K D2 Facies. *Fossiliferous dolomite.*

More of a rudstone than a boundstone.

Hole continues to 83.8 m Not logged at this time.

Cominco D.D.H. 4312

0 - 10.5 Casing/Overburden.

10.5 - 27.1 SLAVE POINT FORMATION.

10.5 - 22.6 N Facies. *Variable sequence of limestone and dolomite.*

22.6 - 27.1 Amco Member.

22.6 - 22.9 M2 (Upper Amco). *Fossiliferous limestone.*

22.9 - 25.9 M1 (Amco Shale). *Marl.*

25.9 - 27.1 M3 (Lower Amco). *Fossiliferous limestone.*

27.1 - 46.6 WATT MOUNTAIN FORMATION.

27.1 - 34.1 Blotchy Member. *Limestone.*

Typical blotchy textured, finely crystalline limestones. Possible, very poorly developed, Amphipora Marker Bed (31.1 - 31.4). Otherwise quite typical.

34.1 - 36.0 Gritty Member. *Argillaceous limestone.*

Again, quite typical. Coarsely intraclastic throughout.

36.0 - 37.8 Upper Micrite. *Micritic limestone.*

Stylolitic, cellular-vuggy, fine, creamy white limestone.

37.8 - 39.3 Upper Shale. *Dolomitic marl.*

Very poor recovery. Bluish-green marl for the most part.

39.3 - 40.8 Lower Micrite? *Fine, dense dolomite.*

Dolomitized to give a dense, finely crystalline, reduction mottled dolomite.

40.8 - 43.9 Silty Dolomite Member. *Fine grained dolomite.*

Light creamy-coffee, finely bedded, finely silty textured dolomite. Very poor recovery persists.

43.9 - 46.6 Lower Shale. *Limy and dolomitic shales and marls.*

Typical dark blue-green limy shales, and dolomitic marls.

46.6 - 47.9 B BIOSTROMAL "FORMATION". *Fossiliferous limestone.*

Limestone, massively fossiliferous, with massive stroms., and lacy corals, in a green and brown clay matrix. Fossils are densely packed, and self-supportive.

Upper contact is extremely rubbly. Basal contact with G5 is sharp some brown clay here. Minor bitumen staining.

47.9 - 48.5 BUFFALO RIVER "FORMATION". *Wispy limestone.*

G5 limestone. Heavy bitumen speckling throughout this medium grey limestone. Toward base unit is almost conglomeratic - but with fossil fragments resting on a massive stromatoporoid, and separated by a veneer of brown clay. Difficult to spot an unconformity,for sure, here???

48.5 - ? SULPHUR POINT FORMATION.

48.5 - ? D2 Facies. *Fossiliferous limestone / dolomite.*

Presqu'ilized from 49.1 m onward - uppermost 60 cm is preserved as limestone and is virtually identical to the B Bio in this vicinity. Within coarsely recrystallized K D2, within characteristic lattice-work like vugs, there is abundant black bitumen.

Hole continues to 83.8 m, not logged at this time.

Cominco D.D.H. 4311

0 - 9.1 Casing/Overburden.

9.1 - 26.8 SLAVE POINT FORMATION.

9.1 - 21.6 N Facies.

Variable sequence of limestone and dolomite.

21.6 - 26.8 Amco Member.

21.6 - 22.3 M2 (Upper Amco).

Fossiliferous limestone.

22.3 - 25.6 M1 (Amco Shale).

25.6 - 26.8 M3 (Lower Amco).

Fossiliferous limestone.

26.8 - 47.2 WATT MOUNTAIN FORMATION.

26.8 - 34.1 Blotchy Member.

Limestone.

(31.1 - 31.4 Amphipora Marker Bed.)

Amphipora floatstone.

34.1 - 35.7 Gritty Member.

Argillaceous limestone.

35.7 - 37.2 Upper Micrite.

Micritic limestone.

37.2 - 38.7 Upper Shale.

Limy and dolomitic shales and marls.

38.7 - 40.2 Lower Micrite.

Fine, dense, dolomite.

40.2 - 43.3 Silty Dolomite.

Fine grained dolomite.

43.3 - 47.2 Lower Shale.

Limy and dolomitic shales and marls.

47.2 – ? SULPHUR POINT FORMATION.

47.2 – ? K D2 Facies.

Fossiliferous dolomite.

Hole continues to 84.1 m, not logged at this time.

Cominco D.D.H. 4310

0 – 11.3 Casing/Overburden

11.3 – 28.4 SLAVE POINT FORMATION.

11.3 – 23.3 N Facies.

Variable sequence of limestone and dolomite.

23.3 – 28.4 Amco Member.

23.3 – 23.8 M2 (Upper Amco).

Fossiliferous limestone.

23.8 – 26.5 M1 (Amco Shale).

Marl.

26.5 – 28.4 M3 (Lower Amco).

Fossiliferous limestone.

28.4 – 48.5 WATT MOUNTAIN FORMATION.

28.4 – 35.1 Blotchy Member.

Limestone.

(32.0 – 32.3 Amphipora Marker Bed)

Amphipora floatstone.

35.1 – 36.6 Gritty Member.

Argillaceous limestone.

36.6 – 38.1 Upper Micrite.

Micritic limestone.

38.1 – 39.6 Upper Shale.

Limy and dolomitic shales and marls.

39.6 – 41.2 Lower Micrite.

Micritic limestone.

41.2 – 43.9 Silty Dolomite.

Fine grained dolomite.

43.9 – 48.5 Lower Shale.

Limy and dolomitic shales and marls.

48.5 – ? SULPHUR POINT FORMATION.

48.5 – ? K D2 Facies.

Fossiliferous dolomite.>

Hole continues to 83.8 m, not logged at this time.

Cominco Test Hole G-4

0 – 6.1 Overburden.

6.1 – 16.2 Cuttings? *No core.*

16.2 – 43.6 WATT MOUNTAIN FORMATION.

16.2 – 35.0 Lower Shale member. *Limy and dolomitic shales and marls.*

Heterogeneous assemblage of light brownish grey limestone and dolomite, grey-green argillaceous dolomite and green shale. Toward base gypsum occurs in small, irregular, veinlets.

35.0 – 43.6 Basal Marine member.*Limestone.*

Dense, fine grained, pinkish grey limestones, for the most part. Stylolitic in part, dolomitic in part. Rare green shale partings.

43.6 – 53.9 B BIOSTROMAL "FORMATION". *Fossiliferous limestone and dolomite.*

Fairly typical development. To approximately 49.0m, interval is distinctly less fossiliferous, is dense, wispy, and vaguely bioturbated in aspect.

From 49.0m onward, interval is distinctly more fossiliferous, containing abundant, light beige coloured, stromatoporoids and corals, within a darker brown, fine limestone matrix.

53.9 – 117.3 BUFFALO RIVER "FORMATION".

53.9 – 56.7 G1 Shale.*Dolomitic shale.*

Medium greenish grey, soft and fissile.

56.7 – 58.8 G B Marker Bed.*Fossiliferous limestone.*

Dense, grey-brown limestone, wispy. Virtually identical to overlying B Biostromal.

58.8 – 109.1 G1 Shale.*Limy shale.*

Thick, monotonous sequence of grey-green, soft, fissile shales.

109.1 – 117.3 G–B transitional. *Argillaceous limestone.*

Competent, brownish grey, richly argillaceous limestone, with locally abundant brachiopod debris.

117.3 – ? PINE POINT FORMATION.

117.3 – ? F facies.*Limestone.*

Typical dense, bituminous, finely planar laminated, tentaculites rich limestone.

Hole continues to 413.0m

Cominco D.D.H. 4640

N.B. Hole extensively sampled by P.E.R.

0 – 34.1 Casing/Overburden.

34.1 – 42.1 WATT MOUNTAIN FORMATION.

34.1 – 40.2? Lower Shale Member. *Limy and dolomitic shales and marls.*
Fairly typical heterogeneous sequence of dull earthy marls and dolomites – light beige-brown to green in colour. Blotchy in part, and often exhibiting a swirled, mottled texture (bioturbated). Characteristic green shales are somewhat less in abundance than might be expected. Unit is dolomitic for the most part, although the uppermost metre or so might be limy – or represent a boulder of younger Watt Mountain out of place, in overburden.

N.B. From 36.9 m on the unit is considerably atypical light brown, earthy, blotchy – perhaps more akin to the Basal Marine Member, but with occassional thin brown shaly/clay seams.

40.2 – 42.1 Basal Marine Member. *Limestone.*
Light greyish brown, fine, dense limestone. Really not typical Basal Marine. Wispier than is perhaps usual – decidedly transitional into underlying B Biostromal. However other sections are fairly typical Basal Marine. Upper and lower contacts taken somewhat arbitrarily at limestone/dolomite contacts.

42.1 – 48.2 B BIOSTROMAL "FORMATION". *Fossiliferous dolomite.*

42.1 – 42.7 Decidedly unusual Amphipora packstone (Dolomitic). Fine, pinkish-cream amphs are extremely densely packed, with a brownish-grey, wispy, typical B Bio matrix.

42.7 – 48.2 Remainder of sequence is quite typical, richly fossiliferous, wispily argillaceous, finely silty textured dolomite, with fairly abundant

fossil moldic vugs. Corals and slender digitate stromatoporoids are most abundant – followed by thick-shelled brachiopods. Some large, and apparently introduced, massive stromatoporoid fragments occur toward the base (46.6 m). Last 1.5 m, unit is significantly less fossiliferous.

48.2 – 90.8? BUFFALO RIVER "FORMATION".

48.2 – 51.2 G1 Shale. *Dolomitic shale.*

Medium greenish-grey, soft and fissile, dolomitic shale. Pyritic, but otherwise fairly featureless.

51.2 – 52.4 G B Marker Bed. *Dolomite.*

Medium greyish-brown, wispily argillaceous limestone – strongly reminiscent of basal B Biostromal Darkest brown toward the top, becoming grey – more Buffalo River like – toward the base – nodular?

52.4 – 85.3 G1 Shale. *Limy shale.*

Extremely uniform sequence of medium grey very slightly greenish – distinctly pyritic, limy shales. An extremely thick development G2 beds are really not well developed. However weakened equivalents may be, in the form of distinctly browner, and more competent limestones – rather uniform in texture, with no nodules developed.i.e.

69.2 – 69.8 (best example)

75.3 – 75.9 (brown colour, but still fairly fissile)

No macrofossils are visible throughout this sequence.

85.3 – 90.8 *Argillaceous limestone.*

Rather unusual sequence – most probably transitional in nature. Very much like a B Marine limestone – but rather clean? Overall light brownish-grey in colour, with fossils, for the most part, rather rare, except for occassional crinoid ossicles and the occassional brachiopod shell fragment. Overall the interval is a dense, finely crystalline limestone with occassional thin interbeds of 'sandier' material –

apparently introduced. There is evidence for debris-flow like activity here on a small scale. These coarser, (introduced), beds are lighter, more beige in colour - and crinoidal debris, especially, seems to be associated with them. The more 'normal' stratigraphy here is a vaguely nodular unit - somewhat like G2 in texture : grey, fine grained, and wispy.

N.B. Hydrocarbon staining is quite intense here - particularly in coarser beds - obscuring some detail.

N.B. Perhaps contact can be extended to 92.7 m? At this point the B Marine fossil assemblage becomes suddenly abundant

90.8 - 92.7 Interval is virtually devoid of macro-fossil - although tentaculites are abundant. This is a fine, grey limestone.

92.7 - 174.0 PINE POINT FORMATION.

92.7 - 100.0 B Marine Limestone -> F Facies. *Biomicrite.*

Very abundant thin-shelled brachiopods and tentaculites, within this fine, grey-brown limestone. Fine wispy laminations throughout - sub-planar on the whole - although occassionally they can be seen to splay about "nodular" features. Such features are quite abundant, and are somewhat reminiscent of G2 in form - however the fauna here is definitely of a B Marine/F Facies affinity.

100.0 - ? F Facies. *Biomicrite.*

Fairly typical, finely planar laminated limestone, with abundant tentaculites, and numerous interbeds of sandier material - introduced??

Hole continues to 195.7 m, not logged at this time.

Cominco D.D.H. 4641

0 - 25.6 Casing/Overburden.

25.6 - 62.2 WATT MOUNTAIN FORMATION.

25.6 - 32.6? Blotchy Member. *Limestone.*

25.6 - 27.7 Upper Blotchy - finely bedded, reduction mottles elongate parallel to bedding. Interval is finely intraclastic in part.

27.7 - 28.0 Amphipora Marker Bed.

28.0 - 32.6 Lower Blotchy - a more competent, more massively bedded, coarsely reduction mottled unit, typical of the lower blotchy member. Entire unit is limestone, except for last 45 cm(which is also slightly earthier, more argillaceous - approaching a Gritty Member?? which is otherwise missing here.

?Core jumbling here?

?32.6 - 34.1? Upper Micrite. *Micritic limestone.*

Typical clean, creamy white, finely crystalline, cellular-vuggy limestone.

?34.1 - 36.0 Upper Shale. *Limy and dolomitic shales and marls.*

Upper half green, gritty, intraclastic - *this looks much like the Gritty Member, jumbled out of position?* - lower half typical, blue-green, dolomitic shale.

N.B. Core recovery is very poor here, and the footage markers are apparently scrambled.

?36.0 - 37.8? Lower Micrite. *Micritic limestone.*

Light, creamy, stylolitic - virtually identical to overlying bed.

?37.8 - 45.1? Silty Dolomite Member. *Fine grained dolomite.*

Extremely well developed here - very thick. Upper half (to 39.9 m) is normal, finely bedded, porous, silty textured dolomite. Distinctive light creamy coffee colour.

The remainder is of similar material, but hosts abundant

(30 – 50%) nodular and banded gypsum and/or anhydrite, producing a distinctive chicken-wire texture. Evaporites such as this effectively obscure the basal contact with the lower shales – which is apparently transitional – the matrix becomes greener with depth.

45.1 – 55.5 Lower Shales. *Limy and dolomitic shales and marls.* Evaporites, as described above, persist to approximately 51.2 m

N.B. 48.2 – 54.3 No footage markers, 4.5 m recovered.

Unit is dolomitic to approximately 51.8 m (in other words, throughout the evaporite association). A short limy sequence is developed to 54.3 m, but beyond that, unit is dolomitic again. Blue-green shales, and earthy marls predominate here.

54.3 – 62.2? Basal Marine Member. *Limestone and dolomite.* Dolomitic – except 57.3 – 60.4. Poor core recovery here, for the most part. (Very bad drilling, grinding of core.) Unit is typically a fine, fairly dense, light coffee-brown, except for interval 60.4 – 62.2, which is highly unusual. Interval is medium dark brown in colour, wispily argillaceous, and full of small white specks?? Very fine Amphipora?? Tentaculites??? Calcispheres????

Note: I've seen this somewhere before.........

Faint reduction mottling occurs throughout the more normal upper sequence – apparently bioturbated.

(60.4)?62.2 – 66.4 B BIOSTROMAL "FORMATION". *Fossiliferous dolomite.*

Richly fossiliferous unit – approximately 30% pinkish-beige corals, digitate stromatoporoids, and thick-shelled brachiopods, with massive stromatoporoids toward the base, in a wispy, bluish-grey, argillaceous matrix – slightly greyer, less brown, than usual. Recovery remains poor – especially toward top.

66.4 – 107.0? BUFFALO RIVER "FORMATION".

66.4 – 68.3 G1 Shale. *Dolomitic shale.*

Medium greenish-grey, soft, fissile, dolomitic shale. (Last 30 cm or so limy.)

68.3 – 69.8 G B Marker Bed. *P.E.R. Sampled.*

Apparently upper half was typical brown, fine carbonate here preserved as limestone – lower half was greyer, more akin to G2 than B Bio. (Unfortunately there is insufficient core remaining to sample for conodonts.)

69.8 – 81.7 G1 Shale. *Limy shale.*

Soft, fissile, limy shale. Very uniform, monotonous sequence.

81.7 – 84.7 *Argillaceous limestone.*

Very poor recovery, and broken/ground core. Unfortunately the G2 bed was somewhere in here – most likely 83.5 – 84.7. It is represented as a much more competent limestone unit.

84.7 – 91.4 G1 Shale. *Limy shale.*

As above, as always. May extend to 93.6 m? Poor recovery here, footage uncertain.

?93.6 – 94.2? G2 Nodular. *Nodular argillaceous limestone.*

Very much as described above – core is again broken, recovery poor.

94.2 – 103.3 G1 – soft, fissile, limy shale.

103.3 – 107.0 G-B Transitional? *Argillaceous limestone.*

Somewhat variable, finely crystalline, dense, light grey, (slightly brownish) limestone. Scattered, rather rare brachiopods lend a B Marine character in part. A vaguely burrowed, blotchy texture is also developed in part.

107.0 – 174.0 PINE POINT FORMATION.

107.0 – 111.3 B Marine Limestone. *Biomicrite.*

The fauna associated with B Marine becomes markedly abundant here,

as do tentaculites. The unit also becomes appreciably wispier, browner, and more petroliferous.

11.3 – ? F Facies. *Biomicrite.*

except: 113.4 – 116.1 more B marine like, coarser grained, with crinoidal debris (poss. TURF?). Also interbeds of "n–like", mottled material – bioturbated? esp. 114.3 – 114.6 and 113.4 – 113.7. Almost G like in colour.

Hole continues to 198.1 m, not logged at this time.

Cominco D.D.H. 5557

0 – 17.7 Casing/Overburden.

17.7 – 19.2 SLAVE POINT FORMATION.

17.7 – 19.2 Amco Member.

17.7 – 19.2 M3 (Lower Amco). *Fossiliferous limestone.*

Bulbous and digitate stromatoporoids, with oncolitic rims, in wispy matrix.

19.2 – 57.0 WATT MOUNTAIN FORMATION.

19.2 – 29.6? Blotchy Member. *Limestone predominantly.*

19.2 – 24.4 Upper Blotchy typically more finely bedded, with finer, more elongate reduction mottles, and intermittent intraclastic beds.

24.4 – 24.7 Amphipora Marker Bed – somewhat poorly developed.

24.7 – 29.6? Lower Blotchy with characteristic coarse reduction mottles throughout. Toward base unit becomes a little greener, more marly in nature. However no true gritty bed is developed?

29.6 – 31.1 Upper Micrite. *Micritic limestone.*

Typical, extremely well developed, fine white limestone. Stylolitic cellular vuggy porosity.

31.1 – 33.8? Upper Shale. *Limy and dolomitic shales and marls.*

Dull, earthy, blue green marls predominate here (dolomitic) sandwiched by more gritty textured, green, wispy limestones.

33.8? – 35.4? Lower Micrite. *Micritic limestone.*

Virtually identical to Upper Micrite.

35.4? – 37.2 Silty Dolomite Member. *Fine grained dolomite.*

Typical, finely bedded, extremely porous, finely silty, creamy-coffee coloured dolomite.

37.2 – 40.5 Silty Dolomite continues, but hosting extensive evaporitic material – both banded and nodular – throughout. This evaporite

development seemingly straddles the Silty Dolomite/ Lower Shale contact.

40.5 – 50.9 Lower Shales. *Limy and dolomitic shales and marls.*

Dolomitized to approximately 46.0 m Fairly typical heterogeneous sequence of green shales, marls, and flaser-bedded limestones. Evaporites are absent after 41.8 m Occassionally both intraclastic and charophyta? rich beds are locally developed.

50.9 – 57.0 Basal Marine Member. *Limestone.*

Thick sequence of med./light, finely crystalline, dense limestones. Finely bedded, wispy in part. Characteristic dolspar blebbed/burrowed texture developed in lower half. Fine shelly debris can be seen here – most probably ostracods? Intermittent green and brown clay bands occur – especially in upper half i.e. 53.9 m Lowermost 30 cm hosts white, vaguely elongate specks as described in other holes – possibly charophyta???? or very slender amphipora?????

57.0 – 61.6 B BIOSTROMAL "FORMATION". *Fossiliferous dolomite.*

Medium light, slightly greyish-brown, wispilly argillaceous dolomite. Perhaps very finely silty textured, to finely crystalline. Fossil debris is abundant from around 58.5 m onward. Lacy corals, and digitate stromatoporoids are especially abundant, with lesser massive stromatoporoid fragments, pancake stromatoporoids, and some thick shelled brachiopods. Deep chocolate brown wisps frequently horsetail and splay about these fragments – and these also become more abundant from 58.5 m

61.6 – 86.0 BUFFALO RIVER "FORMATION".

61.6 – 63.4 G1 Shale. *Dolomitic shale.*

Medium greenish-grey, soft,fissile, dolomitic shales (degraded in part to clay).

N.B. The last 30 cm here is extremely unusual. It is somewhat more competent, and hosts up to 25% fossil material lacy corals, thick

ribbed brachiopods, and large crinoid ossicles.

63.4 – 64.3 G B Marker Bed. *Dolomite.*

Extremely well developed here. Dark brown, dense, fine dolomite. Uppermost 15 cm hosts characteristic grey clasts, with extremely well developed concentric colour banding....burrows?? Approximately mid-way through this unit, there is a fairly sharp colour change to grey-brown. Fine shelly debris persists throughout, but in the lower half appears coarser, more detrital in origin? Some large coral fragments can be found here also.

64.3 – 69.8 G1 Shale.*Limy shale.*

Soft, fissile, limy shales. In the uppermost 8 –10 cm some distinctly more competent, light grey nodules are developed. However for the most part the unit is uniform and homogeneous. The occassional ribbed brachiopod shell can be found flat, with a fairly long hinge line.

69.8 – 72.7 G2 *Nodular argillaceous limestone.*

Extremely well developed, quite typical. Large, light grey (micrite?) nodules, in a darker grey, wispy matrix. The overall colour here, especially of the matrix, is slightly brown.

72.7 – 77.1 G1 Shale. *Limy shale.*

Apparently somewhat more competent than usual – although this may be more of a function of the age of the core than anything else.

77.1 – 78.5 G2. *Nodular argillaceous limestone.*

Virtually identical to overlying G2 unit the overall brown hue is distinct – and there is a more abundant fine shelly debris component.

78.5 – 82.3 G1 Shale. *Limy shale.* Soft, fissile, limy – becoming more competent toward base.

82.3 – 82.6 *Argillaceous limestone.*

Somewhat unusual zone. Browner in colour, more competent, with a vaguely burrowed or bioturbated texture.

82.6 – 84.4 G1 Shales. Minor, fine shelly debris occassionally discernible

here.

84.4 – 86.0 *Argillaceous limestone.*

Identical to 82.3 – 82.6 above. Brown-grey, fairly dense, competent, argillaceous, bioturbated limestone, interbedded with shalier, shellier material. Minor crinoidal debris here. Dolomitized toward base.

86.0 – 99.1 PINE POINT FORMATION.

86.0 – 91.4 (K) E Facies. *Dolomite.*

Uppermost 1 – 2.0 m slightly B'ish? Otherwise very clean, sandy, sucrosic dolomite. Grain size decreases with depth.

91.4 – 99.1 E Facies -> E-B Facies. *Dolomite.*

Very minor coralline debris. Lowermost 1 – 2.0 m quite wispy.

E.O.H. @ 99.1 m

Cominco D.D.H. 4343

0 – 15.2 Casing/Overburden.

15.2 – 46.3 WATT MOUNTAIN FORMATION.

15.2 – 21.3 Blotchy Member. *Limestone and dolomite.*

Upper half preserved as limestone, lower half dolomitic – seperated by a well developed Amphipora Marker Bed. Unit is otherwise typical, fine , dense, bioturbated unit upper half more finely bedded, finely blotchy.

N.B. No footage marker 20.4 – 25.9, therefore footages approximate – 4.5 m recovered.

21.3 – 22.9 Gritty Member. *Argillaceous limestone.*

Greenish, dull, earthy, reduction mottled marls – interbedded with shalier, gritty textured beds. Intraclastic for the most part – occassionally hosting charophyta.

22.9 – 24.4 Upper Micrite. *Micritic limestone.*

Typical clean, vuggy limestone.

24.4 – 25.6 Upper Shale. *Limy and dolomitic shales and marls.*

Upper half limy marls and shales, lower half characteristic blue-green shale.

25.6 – 27.1 Lower Micrite. *Micritic limestone.*

Very similar to upper micrite – recovery rather poor however.

27.1 – 32.6 Silty Dolomite Member. *Fine grained dolomite.*

Rather thickly developed. Creamy-coffee coloured, extremely porous, with interbeds of brecciated material – most probably the result of intrastratal collapse from evaporite dissolution.

32.6 – 41.1 Lower Shales. *Limy and dolomitic shales and marls.*

Dolomitic, except for 36.6 – 38.4 which is limy. Typical heterogeneous sequence of green shales and marls (bioturbated in part) and cleaner limestones – often flaser-bedded and/or intraclastic.

Shalier beds perhaps host charophyta.

41.1 – 46.3 Basal Marine Member. *Dolomite.*

Somewhat uncharacteristically dolomitized throughout (bordering on Presqu'ile??) – otherwise a fairly uniform, light med. brownish-grey, dense, finely silty textured unit. Faintly wispy in part, becoming darker with depth. N.B. Fine white specks @ contact?

46.3 – 50.9 B BIOSTROMAL "FORMATION". *Fossiliferous dolomite.*

46.3 – 48.2 Relatively unfossiliferous unit – much like overlying Basal Marine Mmbr., but slightly darker, more wispy.

48.2 – 50.9 Fairly richly fossiliferous. Abundant corals and digitate stromatoporoids? with pancake stromatoporoids and thick-shelled brachiopods, in a wispy, dolomitic matrix.

50.9 – 66.8 BUFFALO RIVER"FORMATION".

50.9 – 52.1 G1 Shale. *Dolomitic shale.*

Fissile, dolomitic shale.

52.1 – 52.7 G B Marker Bed. *Dolomite.*

Rather poor recovery of a medium brown, dense dolomite, with very sharp upper and lower contacts.

52.7 – 56.7 G1 Shale. *Limy and dolomitic shales.*

Uppermost 1.0 m contains (rare) light grey micritic nodules. Remainder is typical fissile, limy shale. Dolomitized from 56.0 m onward.

56.7 – 58.2 G2 *Nodular argillaceous dolomite.*

Interval has been dolomitized, resulting in a more "sandy" textured unit. Nonetheless macro-textures have been preserved – light grey nodules, in a wispy matrix.

58.2 – 61.3 G1 Shale.*Dolomitic shale.*

Fissile.

61.3 – 62.8 G2 *Nodular argillaceous dolomite.*

62.8 – 65.2 G1 Shale.*Dolomitic shale.*

Fissile.

65.2 – 66.8 Mixture of shales, and more competent, G3 like material.

Brecciated in part – but core is missing here – P.E.R.????

66.8 – 99.1 PINE POINT FORMATION.

66.8 – 80.2 E Facies. *Dolomite.*

Very slightly Presqu'ilized.

80.2 – 82.6 B Marine Dolomite. *Dolomitized biomicrite.*

Very 'grey' looking.

82.6 – 87.5 E Facies. *Dolomite.*

87.5 – 89.9 B Marine Dolomite. *Dolomitized biomicrite.*

89.9 – 95.7 B Marine Limestone. *Biomicrite.*

95.7 – 99.1 F Facies.

Biomicrite.

E.O.H. @ 99.1 m

Cominco D. D. H. 4342

0 – 14.6 Casing/Overburden.

14.6 – 16.5 SLAVE POINT FORMATION

14.6 – 16.5 Amco Member.

14.6 – 15.2 M1 (Amco Shale). *Marl.*

15.2 – 16.5 M3 (Lower Amco) *Fossiliferous limestone.*

16.5 – 48.8 WATT MOUNTAIN FORMATION

16.5 – 24.7 Blotchy Member. *Limestone and dolomite.*

Typical upper and lower half, separated by well developed Amphipora Marker Bed (21.3 – 21.6). Unit is limy for the most part, however 22.6 – 23.2 is dolomitic.

24.7 – 25.9 Gritty Member. *Argillaceous limestone.*

Earthy reduction mottled marls, interbedded with richly argillaceous, intraclastic beds.

25.9 – 27.4 Upper Micrite. *Micritic limestone.*

Typical, clean, faintly stylolitic, vuggy limestone, almost milky white in colour.

27.4 – 29.9 Upper Shale. *Limy and dolomitic shales and marls.*

Alternating sequences of charophyta rich marls and green shales, with cleaner limestones (crypto-crystalline? in texture, 'chalky') Unit is limy throughout.

29.0 – 29.3 Brecciated – intrastratal collapse.

29.9 – 30.8 Lower Micrite. *Micritic limestone.*

Patchily stained a faint purplish colour – otherwise typical vuggy limestone. Staining apparently enhances bedding features.

30.8 – 35.7 Silty Dolomite Member. *Fine grained dolomite.*

Typical, but rather thick sequence of silty textured, finely bedded extremely porous dolomite. Veined and brecciated in part – apparently

the result of evaporite dissolution?

35.7 – 43.3 Lower Shales. *Limy and dolomitic shales and marls.*

(Dolomitized to approx. 39.6 m and again from 40.6 m onward.) Usual sequence of green shales and marls, interbedded with cleaner limestones – usually discretely wispy.

43.3 – 48.8? Basal Marine Member. *Dolomite.*

Fairly uniform, dense, finely sandy, med./light brownish grey *dolomite.* N. B. 47.2 – 47.5 Very strongly recrystallized – almost Presqu'ilized. The entire unit is much more strongly recrystallized than normal.

?48.8 – 53.3? B BIOSTROMAL "FORMATION". *Fossiliferous dolomite.*

Recovery is rather poor here. Otherwise interval appears typical.

?53.3 – 63.1 BUFFALO RIVER "FORMATION".

53.3 – 54.0 Pieces of either the G B Marker Bed, or the end of B Biostromal. If the latter, then both the upper G1 and the G B Marker Bed are missing, if the former, then only the upper G1 is missing. *Driller's note "seam 4ft" at 53.6 m level?*

54.0 – 56.7 G1 Shale. *Limy shale.*

Extremely soft and fissile limy shales.

56.7 – 58.2 G2. *Nodular, argillaceous limestone.*

Some scattered coralline debris, deforming and draped by wisps.

58.2 – 60.0 G1 Shale. *Dolomitic shale.*

Fissile, med. grey-green shale.

60.0 – 61.6 G2. *Nodular argillaceous limestone.*

61.6 – 63.1 *Shales.*

– but virtually no recovery here. There may have been up to 1.0 m of G5 at the base here???

63.1 – 99.1 PINE POINT FORMATION

K E Facies – E Facies. *Dolomite.*

N. B. Uppermost 60 cm fairly wispy - possibly transitional into G????? Remainder of E sequence extremely clean sandy dolomite.

Hole continues to 99.1 m, not logged at this time.

Cominco D. D. H. 4341

0 – 14.0 Casing/Overburden.

14.0 – 14.9 SLAVE POINT FORMATION

14.0 – 14.9 Amco Member.

14.0 – 14.9 M3 (Lower Amco). *Fossiliferous limestone.*

14.9 – 44.8 WATT MOUNTAIN FORMATION

14.9 – 23.5 Blotchy Member. *Limestone.*

Can be broadly separated into two by an extremely well developed Amphipora Marker Bed (20.1 – 20.6). This bed also contains large bulbous stromatoporoid fragments. The upper Blotchy here is fairly typical, fine dense limestone, with abundant, densely packed, dark, elongate reduction mottles. The lower Blotchy Member here is dolomitic, finely crystalline, dense, and coarsely reduction mottled.

23.5 – 24.7 Gritty Member. *Argillaceous limestone.*

Typical transitional upper contact into a greener, reduction mottled limestone, approaching a marl. The majority of the unit is interbedded intraclastic material, in a more richly argillaceous matrix, becoming shaly in part.

24.7 – 26.2 Upper Micrite. *Micritic limestone.*

Finely crystalline, fairly dense, finely vuggy limestone. Fairly typical.

26.2 – 28.0 Upper Shale. *Limy and dolomitic shales and marls.*

An extremely fissile, blue-green shale (dolomitic) is sandwiched between slightly more competent, intraclastic, shaly limestones, interbedded with cleaner limestones (source of intraclastic material?)

28.0 – 29.0 Lower Micrite. *Micritic limestone.*

(Rather thin.) Extremely clean, quite typical.

29.0 – 34.4 Silty Dolomite Member. *Fine grained dolomite.*

Extremely well developed – typical poor recovery. Overall a finely

bedded, porous to extremely porous, dolomite. Minor gypsum bands and nodules right at the basal contact.

34.4 – 40.8 Lower Shale Member. *Limy and dolomitic shales and marls.* (Dolomitic to 38.7 m) Heterogeneous sequence of green shales, (reduction mottled) marls, and shaly limestones – quite typical.

40.8 – 44.8? Basal Marine Member. *Limestone and dolomite.*

40.8 – 41.8 Limestone. Light pinkish-grey in colour, and riddled with woodworm like holes, partially filled by green clay.

41.8 – 43.6 Distinctive, dolomitized Basal Marine Member. Fine, 'speckled' dolomite, with abundant white dolspar blebs throughout. Medium grey brown in colour, becoming darker with depth.

N. B. 43.6 – 45.1 A more strongly recrystallized zone, with fairly abundant stringers of white dolspar, obscuring the – normally – transitional contact.

?44.8 – 49.4 B BIOSTROMAL "FORMATION". *Fossiliferous dolomite.*

Medium brown, dense, wispily argillaceous dolomite. Fairly fossiliferous – especially lower half – containing matrix supported digitate stromatoporoids primarily. Minor coralline and thick shelled brachiopod debris also present. Fossil moldic vugginess locally well developed – filled by glassy black bitumen.

49.4 – 58.5 BUFFALO RIVER "FORMATION".

49.4 – 50.6 G1 Shale. *Dolomitic shale.*

Medium grey, dolomitic, fissile shale. Quite typical.

50.6 – 50.9 G B Marker Bed. *Dolomite.*

Identical to upper – non-fossiliferous – B Biostromal.

50.9 – 53.6 G1 Shale. *Limy shale.*

Soft, fissile, limy shale. Minor shelly debris.

53.6 – 54.9 G2 *Nodular argillaceous limestone.*

(Heavily sampled by P. E. R.). Nodular, argillaceous limestone.

54.9 – 55.8 G1 Shale. *Limy shale.*

Soft, fissile shale. Minor, more competent, nodules developed.

55.8 – 56.7 G2 *Nodular argillaceous limestone.*

Competent, brownish-grey, nodular argillaceous limestone.

56.7 – 58.5 *Wispy dolomite.*

Finely sandy, wispily argillaceous, fossiliferous dolomite – G4ish G5???

Coralline debris predominates – in upper 30 cm especially.

58.5 – 99.1 PINE POINT FORMATION

58.5 – ? E facies. *Dolomite.*

Uppermost 3.0 – 4.5 m very slightly Presqu'ilized.

Hole continues to 99.1 m, not logged at this time.

Cominco D. D. H. 4340

0 – 13.1 Casing/Overburden.

13.1 – 38.7 WATT MOUNTAIN FORMATION

13.1 – 19.5 Blotchy Member. *Limestone and dolomite.* A typical upper and lower half, separated by a well developed Amphipora Marker Bed 16.8 – 17.1. From 17.1 m onward unit is dolomitic.

19.5 – 21.2 Gritty Member. *Argillaceous limestone.*
Interbedded intraclastic shaly beds, with coarsely reduction mottled marls – hosting fine shelly? debris, and charophyta.

21.2 – 22.6 Upper Micrite. Typical clean, dense, finely vuggy limestone.

22.6 – 24.1 Upper Shale Member. *Limy and dolomitic shales and marls. Upper half coarsely intraclastic,green shaly limestone. Lower half blue-green, dolomitic shales, hosting abundant charophyta.*

24.1 - 25.9 Lower Micrite. Micritic limestone.
Extremely well developed, vuggy, clean, (stylolitic), creamy–beige limestone.

25.9 – 29.6 Silty Dolomite Member. *Fine grained dolomite.*
Light creamy coffee coloured, finely bedded, porous dolomite. Pores are occassionally enhanced by leaching to produce a fine vugginess throughout.

29.6 – 35.7 Lower Shale Member. *Limy and dolomitic shales and marls.*

35.7 - 38.7 Basal Marine Member. Dolomite.
Typical light brown–grey, finely crystalline, speckled textured dolomite. Characteristic white dolspar blebs (ostracod boring???) abundant throughout. Dolomitic throughout. Basal contact with underlying B Biostromal is really quite transitional. However @ 38.7 m the crystallinity changes somewhat, and there are some green and brown clay seams in the vicinity. However, the original texture of the rock, both above and below this, would appear to be identical?

38.7 – 42.7 B BIOSTROMAL "FORMATION". *Fossiliferous dolomite..*

38.7 – 40.5 Wispily argillaceous, bioturbated, finely silty to fine crystalline dolomite – med. brownish grey in colour.

40.5 – 42.7 Becoming increasingly darker, browner in colour, and increasingly fossiliferous. Coralline debris seems to predominate, with slender digitate stromatoporoids and med. shelled brachs.

42.7 – 50.6 BUFFALO RIVER "FORMATION".

42.7 – 43.6 G1 Shale. *Dolomitic shale.*

Medium grey, soft and fissile.

(43.6 – 44.0 G B Marker Bed? *Sampled out.*

44.0 – 46.0 G1 Shale *Limy shales.*

46.0 – 50.6*Argillaceous dolomite?*

Rather poor recovery and heavy sampling here. This is, apparently, initially a richly argillaceous, wispy G3 like unit, becoming a cleaner, more E like G5 toward the base. It also hosts some coralline debris here – coarse, and obviously introduced.

50.6 – 91.4 PINE POINT FORMATION

50.6 – ? E facies. *Dolomite.*

Initially strongly Presqu'ilized – this fades rapidly with depth. Very clean.

Hole continues to 91.4 m, not logged at this time.

Cominco D. D. H. 4338

0 – 15.5 Casing/Overburden.

15.5 – 37.8 WATT MOUNTAIN FORMATION

15.5 – 21.0 Blotchy Member. *Limestone.*

This encompasses an extremely well developed Amphipora Marker Bed. Amphs. are characteristic purplish grey colour, in a light creamy-brown matrix. Entire unit is finely recrystallized, to a very fine sucrosic dolomite.

21.0 – 22.4 Gritty Member. *Argillaceous limestone.*

Material very similar to lower Blotchy, interbedded with both shaly and intraclastic material. The more marly units host charophyta.

22.4 – 23.2 Upper Micrite. *Dolomitized.*

Original micritic limestone, recrystallized to a coarse sucrosic dolomite, at top, grading downward into a denser sucrosic dolomite.

23.2 – 24.7 Upper Shale. *Dolomitic shales and marls.*

Green, dolomitic, charophyta hosting marls, on top of a characteristic blue-green, fissile shale. Lowermost 30 cm transitional into underlying clean limestone.

24.7 – 26.5 Lower Micrite. *Dolomitized.*

Intensely recrystallized to give a coarse, sucrosic, vuggy dolomite approaching the Presqu'ile in intensity. Minor white stringer like veinlets of dolspar.

26.5 – 29.6 Silty Dolomite Member. *Fine grained dolomite.*

Normal dull, almost earthy textured, finely bedded, porous dolomite. Apparently very little affected by this later phase of dolomitization.

29.6 – 36.0 Lower Shale unit. *Dolomitic shales and marls.*

Typical mixed sequence of green shales, marls and wispy dolomites almost chalky in texture. In lower half, unit is coarsely recrystallized to give a 'salt and pepper' texture.

N. B. There is a clear association apparent here: Original limestones are intensely affected by secondary dolomitization. Original dolomites (i. e. Silty Dolomite, upper Lower Shale) are virtually unaffected.

36.0 – 37.8? Basal Marine Member. *Dolomite.*

Medium brown, finely sucrosic, speckled dolomite. Dolspar blebs abundant.

?37.8 – 39.9 B BIOSTROMAL "FORMATION". *Dolomite.*

There is karst involvement in the contacts here.

A fine crackle brecciation can be seen to develop within this unit. Apparently only the upper (non–'biostromal') half is preserved here. Seen as a med. light brown, finely silty, dense, competent, wispy dolomite.

?39.9 – 54.9? BUFFALO RIVER "FORMATION".

Strongly karsted and crackle brecciated.

39.9 – 44.2 Soft, fissile shales predominate.

44.2 – 65.8? More competent lithologies G2 and G5 apparently.

?54.9 – 76.2 PINE POINT FORMATION

?54.9 – 65.8? Karsted K BRS facies.

65.8 – ? K BRS facies.

Hole continues to 76.2 m, not logged at this time.

Cominco D. D. H. 4339

0 – 13.4 Casing/Overburden.

13.4 – 34.1 WATT MOUNTAIN FORMATION

13.4 – 20.4 Blotchy Member. *Limestone and dolomite.*

Amphipora Marker Bed (14.9 – 15.2) separates a limy upper half from a dolomitic lower half. Quite typical.

20.4 – 21.9 Gritty Member? *Argillaceous dolomite?*

Rather poor recovery, however unit must have been in this vicinity? Dolomitized.

21.9 – 23.5 Upper Micrite. *Dolomite.* Quite severely recrystallized to a coarse sucrosic dolomite. However, unit is recognizably clean, and cream in colour.

23.5 – 25.9 Upper Shale. *15 cm only of green shale recovered.*

25.9 – 29.3? Lower Micrite and Silty Dolomite. *Dolomite.*

Extremely poor recovery renders the two indistinguishable. Nodular evaporites appear in last 30 cm There are indications of intrastratal collapse throughout.

?29.3 – 32.0 Lower Shales. *Limy and dolomitic shales and marls.*

(Dolomitic to 30.8 m) Heterogeneous sequence of green shales, marls and chalky dolomites. Uppermost 30 cm host approx. 80% bands of gypsum.

32.0 – 34.1 Basal Marine Member. *Limestone and dolomite.*

Uppermost 30 cm limy – remainder dolomitic. Typical, pinkish beige, bored/burrowed limestone grading into a speckly textured, brownish dolomite, with abundant white dolspar blebs.

N. B. Base here is very strange. Possible unconformity – 15 cm of cemented rubble recovered, along with green clay seams. Very distinctive top to B Bio?

34.1 – 37.8 B BIOSTROMAL "FORMATION". *Fossiliferous dolomite.*

A rather unfossiliferous interval. Medium brown, finely crystalline dolomite, wispy and crackle brecciated in part – especially toward the base. Fossils are present – rather uncharacteristically – toward the top of the unit. They include scattered lacy corals, and (possibly) massive stromatoporoids. Unit has a distinctly bioturbated look throughout.

37.8 – 42.1 BUFFALO RIVER "FORMATION".

(Karsted toward base.)

37.8 – 38.7 G1 Shale. *Dolomitic shales.*

38.7 – 39.0 G B Marker Bed.*Dolomite.*

G1 Shale. *Dolomitic shales.*

40.5 – 42.1 Crackle-brecciated, competent, sandy Buffalo River possibly al G5?? (core has been split).

42.1 – 91.4 PINE POINT FORMATION

42.1 – ? Karsted K BRS facies. Quite E'ish to about 44.2 m Abundant I/S, white and blue vein dolspar.

Hole continues to 91.4 m, not logged at this time.

Cominco D. D. H. 4337

0 – 15.2 Casing/Overburden.

15.2 – 36.0 WATT MOUNTAIN FORMATION

15.2 – 19.2 Blotchy Member. *Limestone.*

Limestone throughout, and divided by an extremely well developed Amphipora Marker Bed (16.5 – 16.9). The upper Blotchy is a little more finely bedded in appearance, the lower Blotchy more coarsely reduction mottled.

19.2 – 21.0 Gritty Member. *Argillaceous limestone.*

Quite well developed, somewhat richly argillaceous unit – intraclastic for the most part. More marly beds often host charophyta. The central portion of this interval is cleaner, more competent, and is more akin to the Blotchy Member.

21.0 – 22.7 Upper Micrite. *Micritic limestone.*

Quite clean, vuggy, stylolitic micrite. Characteristic creamy white colour. Quite normal.

22.7 – 24.4 Upper Shale. *Limy and dolomitic shales and marls.*

A typical, dolomitic, blue-green shale, sandwiched by more 'gritty' textured limestones and marls – all green, and quite richly argillaceous.

24.4 – 26.2 Lower Micrite. *Micritic limestone.*

Clean, beige, extremely vuggy limestone. Abundant fine lath-like vugs and gypsum pseudomorphs locally developed. (Motheaten style vugginess possibly enlarged version of these leached crystals??)

26.2 – 29.3 Silty Dolomite Member. Fairly typical, finely bedded, silty, porous, clean, E-like? dolomite.

29.3 – 33.2 Lower Shales. *Limy and dolomitic shales and marls.*

Heterogeneous sequence of green shales and marls, with some cleaner limestones. Dolomitic to 32.3 m, quite typical.

33.2 – 36.0 Basal Marine. *Limestone.*

Nevertheless shaly zones persist throughout. Quite interesting pinkisk-cream limestone, with well developed birdseye textures in part, and with locally abundant green shale/marl rip-up clasts. Toward base unit develops more typical bored appearance.

Unit ends extremely abruptly, with fragments of richly coralline material and a thin brown clay seam at contact. *This is a extremely interesting contact.* Thamnoporal coral rock possibly derived from more reefal B Biostromal to the south (where else?)? This is totally unlike anything else I have seen. Densely packed corals, preserved in sub-angular limestone fragments - surely in place - and smeared with green clay.

Evidence of unconformity??

Basal Marine Member here may show dessication cracks. This is also a limestone-dolomite contact.

36.0 - 40.5 B BIOSTROMAL "FORMATION". *Fossiliferous dolomite.*

Upper half typical dense, bioturbated, wispy dolomite. Lower half contains scattered Thamnopora sp. corals and slender digitate stromatoporoids. (This fossiliferous B Biostromal is quite unlike the fragments described above.) Fossils are never very abundant.

40.5 - 44.8? BUFFALO RIVER "FORMATION".

Unit has been heavily sampled bu P. E. R. It was apparently an upper third dominated by shales, followed by a wispily argillaceous, sandy textured dolomite and finally a G5.

44.8 - 50.6? SULPHUR POINT FORMATION

44.8 - ? K D2 facies. *Fossiliferous dolomite.*

Hole continues to 76.2 m, not logged at this time.

Cominco D. D. H. 4336

0 – 14.0 Casing/Overburden.

14.0 – EOH SINKHOLE.

Quite typical example of downdropped and tilted boulders of more or less normal stratigraphy, beginning with N facies. Bedding is frequently angled – occassionally vertical.

Rough stratigraphy:

14.0 – 35.0 N & M facies.

35.0 – 62.5 Watt Mountain Formation

62.5 – 68.5 Buffalo River

68.5 – ? K D2 facies.

E. O. H. @ 76.2 m

Cominco D. D. H. 4335

0 – 14.9 Casing/Overburden.

14.9 – 17.4 SLAVE POINT FORMATION

14.9 – 17.4 Amco Member

14.9 – 17.4 M3 (Lower Amco) *Fossiliferous limestone.*

More or less typical, wispily argillaceous limestone, hosting approximately 15% stromatoporoid debris – generally bulbous, and pinkish in colour, with purplish, bitumen stained, oncolitic rims. Wisps within the matrix splay about such fragments.

17.4 – 40.8 WATT MOUNTAIN FORMATION

17.4 – 24.4 Blotchy Member. *Limestone*

Encloses an extremely well developed Amphipora Marker Bed (21.2 – 21.6), typical, with purplish grey amphipora, in a light coffee matrix. This member is, for the most part, limestone throughout. Lower half is characteristically coarsely reduction mottled, with interbeds of coarsely intraclastic material. Fragments have a dark grey stain, and are algal/oncolitic rimmed.

24.4 – 25.9 Gritty Member. *Argillaceous limestone.*

Well developed, quite richly argillaceous, finely intraclastic for the most part, and hosting occassional charophyta.

N. B. One large strom. fragment can also be found here distorting laminae, and obviously introduced.

25.9 – 27.4 Upper Micrite. *Micritic limestone.*

Typical clean, light, cream limestone. Finely crystalline, not especially vuggy.

27.4 – 29.0 Upper Shale. *Limy and dolomitic shales and marls.*

Upper half flaser bedded. Richly argillaceous 'gritty' beds overlie typical blue-green dolomitic shale.

29.0 – 30.5 Lower Micrite. *Micritic limestone.*

Typical, dense, extremely vuggy, clean, creamy beige limestone.

30.5 – 33.5 Silty Dolomite Member. *Fine grained dolomite.*

Extremely typical, finely bedded, silty textured dolomite. Porous.

33.5 – 35.1 Transitional zone? Very siightly greenish, silty dolomite-textured unit, replaced by approximately 30% irregular bands and blebs of gypsum.

35.1 – 39.6 Lower Shale Member. *Limy and dolomitic shales and marls.*

Dolomitic to 36.9 m Heterogeneous sequence of green shales, and somewhat cleaner, more competent marls, with flaser bedded material.

39.6 – 40.8 Basal Marine Member. *Limestone.*

Fairly well developed. Finely crystalline, fairly dense, typical pinkish-beige colour, with characteristic 'riddled' or bored texture. Rare, random, green shale seams or partings.

40.8 – 43.0 B BIOSTROMAL "FORMATION". *Fossiliferous limestone.*

A richly fossiliferous unit – massive stromatoporoids predominate especially in lower half. Corals appear more toward top. This unit is distinctly reefal in aspect. Limey for the most part, there is virtually no matrix material here.

43.0 – 45.1 BUFFALO RIVER"FORMATION"

Upper half richly wispy, dark grey, sandy dolomite lower half cleaner, sandy unit.

45.1 – ? SULPHUR POINT FORMATION

45.1 – ? K D2 facies. *Fossiliferous dolomite.*

Hole continues to 91.4 m, not logged at this time.

Cominco D. D. H. 4334

0 – 16.5 Casing/Overburden.

16.5 – 19.2 SLAVE POINT FORMATION

16.5 – 19.2 Amco Member.

16.5 – 18.6 M1 (Amco Shale). *Marl.*

Limey, med. grey marl.

18.6 – 19.2 M3 (Lower Amco). *Fossiliferous limestone.*

Wispily argillaceous limestone. Scattered bulbous stromatoporoid and crinoidal debris. Coearsely intraclastic in part (especially toward top) somewhat atypical. Minor dark purplish-grey bitumen staining.

19.2 – 40.5 WATT MOUNTAIN FORMATION

19.2 – 26.8 Blotchy Member. *Limestone.*

Fairly typical development of finely crystalline (finely intraclastic in part), reduction mottled (boiturbated),limestones enclosing an extremely well developed Amphipora Marker Bed.

26.8 – 28.4 Gritty Member. *Argillaceous limestone.*

Interbedded cleaner, intraclastic limestones, with marls, and extremely intraclastic shales.

28.4 – 29.9 Upper Micrite. *Micritic limestone.*

Dense, finely crystalline, faintly bitumen speckled limestone. Vugginess very poorly developed here.

29.9 – 30.8 Upper Shales. *Limy and dolomitic shales and marls.*

Upper half is characteristically, and typically, almost identical to the upper half of the Gritty Member – limey. It overlies an extremely fissile, dolomitic, blue-green shale.

30.8 – 32.9 Lower Micrite. *Micritic limestone.*

Dense, clean, finely crystalline limestone. Fine stylolites fairly well

developed. Fine motheaten style vugginess.

32.9 – 35.7 Silty Dolomite Member. *Fine grained dolomite.*

Fairly typical, finely bedded, porous, silty textured dolomite. Signs, in part, of intrstratal collapse from evaporite dissolution.

35.7 – 40.2 Lower Shale Member. *Limy and dolomitic shales and marls.*

(Upper half dolomitic). Fairly typical, heterogeneous assemblage of green shales, and flaser bedded, cleaner carbonates. In lower half, unit is considerably cleaner, with distinct shale beds, and some strangely textured (birdseye?) micrites.

40.2 – 40.5 Basal Marine Member. *Limestone.*

Pinkish beige micrite.

40.5 – 43.6 B BIOSTROMAL "FORMATION". *Fossiliferous limestone.*

Here preserved as limestone, and extremely 'biostromal'. Massive stromatoporoids predominate, with lesser *Thamnopora* sp. Stromatoporoids are as much as 45 cm thick. Corals, especially, seem to occur in a green and brown clay matrix. Nevertheless, they are extremely densely packed, and entirely self-supportive. Clay could be post-depositional?? Some thick-shelled brachiopod debris also occurs here.

43.6 – 46.9 BUFFALO RIVER "FORMATION". *Wispy limestone / dolomite.*

G5, sandy textured *limestone* for the most part although upper 15 cm is dolomitized. Very unusual. Finely bedded – faintly wispy in part.

N. B. Lowermost 15 cm extremely interesting here – more coarsely clastic in appearance, with some thick-shelled brachs. This sits directly on K D2. Unconformity????

46.9 – ? SULPHUR POINT FORMATION

46.9 ? K D2 facies. *Fossiliferous dolomite.*

Hole continues to 76.5 m, not logged at this time.

Cominco D. D. H. 4333

0 – 14.0 Casing/Overburden.

14.0 – 18.0 SLAVE POINT FORMATION

14.0 – 18.0 Amco Member.

14.0 – 14.3 M2 (Upper Amco). *Fossiliferous limestone.*

14.3 – 16.8 M1 (Amco Shale).

Marl.

16.8 – 18.0 M3 (Lower Amco). *Fossiliferous limestone.*

Abundant pink bulbous stromatoporoids, with dark purplish-grey, oncolitic rims. These fossils float in a wispily argillaceous, in part finely bioclastic, matrix – a greyish coffee-brown in colour.

18.0 – 37.5 WATT MOUNTAIN FORMATION

18.0 – 25.6 Blotchy Member. *Limestone.*

Quite typically finely reduction mottled, to coarsely mottled. Finely crystalline, dense limestones, hosting Amphipora Marker Bed 22.3 – 22.6.

25.6 – 27.1 Gritty Member. *Argillaceous limestone.*

Wispily argillaceous, 'gritty', intraclastic limestone – varying from a shale to a dirty limestone.

27.1 – 28.7? Upper Micrite.*Micritic limestone.*

(Poor recovery). Fine, dense, cream limestone.

?27.1 – 29.3? Upper Shale. *Limy shale.*

15 cm only of green shale recovered.

?29.3 – 30.2? Lower Micrite. *Micritic limestone.*

Poor rcovery – very similar to Upper Micrite.

?30.2 – 34.4? Silty Dolomite Member. *Fine grained dolomite.* Extremely poor recovery – light coffee-brown silty textured dolomite.

?34.4 – 37.5? Lower Shale. *Limy and dolomitic shales and marls.*

Upper half dolomitic. Typical heterogeneous sequence of shales, marls, and flaser bedded limestones.

?37.5 – 39.6? B BIOSTROMAL "FORMATION".

Highly fossiliferous? Virtually no recovery – very hard to identify.

39.6 – 41.8 UNKNOWN? 100% Marcassite replaced. Originally G5? Has the same apparent texture.

41.8 – ? SULPHUR POINT FORMATION

41.8 – ? K D2 facies. *Fossiliferous dolomite.*

Hole continues to 76.2 m, not logged at this time.

Cominco D.D.H. 4352

0 – 17.4 Casing/Overburden.

17.4 – 35.7 WATT MOUNTAIN FORMATION.

17.4 – 20.1 Poor recovery here. This appears to be more akin to the Silty Dolomite member, transitional into the Lower Shale? Strongly banded and veined by gypsum, creamy brown dolomite.

20.1 – 31.4 Lower Shale member. *Dolomitic shales and marls.*

Thickly developed, and dolomitic throughout (somewhat unusual). Bluish green, dolomitic marls predominate, with some shalier beds, and some cleaner, cryptocrystalline dolomite – almost chalky looking pale brownish cream in colour.

31.4 – 35.7 Basal Marine member. *Limestone.*

Medium grey brown, dense, finely crystalline limestone. Wispy laminated in part. Characteristic white dolspar blebs also developed in part. Unit is limestone throughout, is apparently devoid of macrofossil, but does show sign of bioturbation and burrowing.

35.7 – 40.4 B BIOSTROMAL "FORMATION". *Fossiliferous dolomite.*

Quite typical. Initially dark–medium brown, wispy laminated dolomite, becoming increasingly darker in colour, and increasingly fossiliferous with depth. Pancake stromatoporoids., thick brachiopods., and fine corals are about equally abundant. Basal contact with Buffalo River is extremely sharp.

40.4 – 60.7 Buffalo River "Formation".

40.4 – 41.8 G1 Shale. *Dolomitic shale.*

Soft, fissile, medium grey, dolomitic shale.

41.8 – 42.8 G B Marker Bed. *Dolomite.*

More or less identical to overlying B Biostromal. Devoid of fossils, but vaguely bioturbated in aspect.

42.8 – 43.3 G2 *Nodular argillaceous dolomite.*

Slightly more competent than underlying G1 shale.

43.3 – 46.3 G1 Shale. *Limy shale.*

Extremely soft and fissile, limy shales.

46.3 – 49.4 Only 75 cm recovered, of a strongly competent, dense, grey limestone. Vaguely disturbed in aspect, finely crystalline. Possible G3 or G2?

49.4 – 52.7 G1 Shale. *Limy shale.*

Soft, fissile.

52.7 – 54.6 G2 *Nodular argillaceous limestone.*

Distinctly more competent, nodular, richly argillaceous limestone.

54.6 – 60.7 G1 Shale. *Limy shale.*

For the most part a soft, fissile, shale with rather rare, and sporadic, limestone nodules, which are especially abundant 58.2 – 59.1

The basal contact with E facies is very sharp – although, for the lowermost 60 cm the shale is interbedded with a more competent, grey, argillaceous limestone.

60.7 – 76.2 PINE POINT FORMATION

There is a sharp change, to an E like, dolomitic, sandy textured unit, but which hosts fairly abundant grey wisps. This style of transitional unit persists to 63.0 m, whereupon a true (clean), porous E–B prevails to.....

E.O.H. @ 76.2 m

Cominco D.D.H. 4351

0 – 19.5 Casing/Overburden.

19.5 – 40.8 WATT MOUNTAIN FORMATION

19.5 – 20.4 Lower Micrite. *Micritic limestone.*

20.4 – 24.1 Silty Dolomite member. *Fine grained dolomite.*

Light creamy coffee coloured, finely bedded, finely porous, finely silty textured dolomite. Fine veinlets of gypsum and/or anhydrite occur sporadically throughout, generally parallel to bedding.

24.1 – 25.9 Basically a transitional zone from the Silty Dolomite into the underlying green shales. It is characterized by abundant gypsum, in bands and nodules, constituting at least 30% of the interval. Original rock here is a greenish, silty textured dolomite, transitional into a marl.

25.9 – 35.4 Lower Shale member. *Limy and dolomitic shales and marls.*

Quite typical sequence of dark bluish green marls, and more fissile shaly material. A rather unusually uniform sequence.

35.4 – 40.8 Basal Marine member. *Dolomite.*

Uppermost 60 cm is somewhat transitional in character, being light creamy beige in colour, and dull, earthy in texture. A cryptocrystalline dolomite, identical to that noted in same transition in D.D.H. 4352. Remainder of interval is a typical, fine, dense dolomite. Wispily argillaceous in part, dolspar blebs in part, becoming distinctly darker brown in colour as unit grades transitionally down into.....

40.8 – 45.1 B BIOSTROMAL "FORMATION". *Dolomite.*

Dark brown, dense, wispy dolomite. Finely crystalline, and devoid of fossils to a depth of 43.0 m, whereupon corals and digitate stromatoporoids become abundant. This unit, also, seems to darken with depth.

45.1 – 61.6 BUFFALO RIVER "FORMATION".

45.1 46.5 G1 Shale. *Dolomitic shale.*

Soft, fissile, dolomitic shale.

46.5 – 47.2 G B Marker Bed. *Dolomite.*

Virtually identical to uppermost B Biostromal.

47.2 – 54.6 ???? G1 Shale. *Limy shale.*

Soft, fissile and limy. Pieces of G2 occur sporadically, apparently out of place.

47.9 - 53.9 jumbled core - box may have been dropped??

i.e. 47.9 - 50.9, 4.5 m recovered.

50.9 - 53.9, 30 cm recovered??

From 47.2 - 54.6 G1 shale no doubt predominated, probably hosting one G2 nodular horizon.

54.6 – 57.0 G2 *Nodular argillaceous limestone.*

Wispily argillaceous matrix, splaying about clean, light grey nodules.

57.0 – 59.1 G1 Shale. *Dolomitic shale.*

Soft, grey, fissile, dolomitic shales.

59.1 – 60.3 G3 *Argillaceous limestone.*

Competent, medium grey, argillaceous limestone, vaguely bioturbated in texture. This unit is somewhat lighter in colour – a little browner.

60.3 – 61.6 G1 Shale. *Limy shale.*

Soft, fissile, limy shales.

61.6 – 62.5 G–E? *Argillaceous dolomite.*

Quite a transitional interval. a B'ish E like, sandy dolomite, hosting abundant, bluish grey, Buffalo River like argillaceous wisps.

62.5 – ? PINE POINT FORMATION

62.5 – ? E facies. *Dolomite.*

Quite typical, porous, sandy dolomite. Somewhat B'ish toward top, but otherwise completely normal, clean, E facies.

E.O.H. @ 76.2 m

Cominco D.D.H. 5707

0 – 19.5 Casing/Overburden.

19.5 – 30.2 WATT MOUNTAIN FORMATION

19.5 – 26.4 Lower Shale member. *Limy and dolomitic shales and marls.*

Upper half light grey to greenish grey to green, argillaceous dolomites. Dull, earthy textured. Very soft and fissile in part. Generally a fairly homogeneous mixture of clay and dolomite. Unit is more variable in colour than in texture.

Lower half similar to above, but limy. Also unit is more shaly, more argillaceous, except for lowermost metre or so, which is a more competent, earthy, argillaceous dolomite.

26.4 – 30.2 Basal Marine member. *Dolomite.*

Light to medium brown-grey, sandy dolomite, somewhat patchily coloured. Minor dolspar veining, with small patchy blebs in lowermost 30 cm. A vague recrystallization texture results in the "sandy" texture. Unit becomes darker with depth. The upper half is faintly laminated, but also appears to be slightly recrystallized.

30.2 – 34.7 B BIOSTROMAL "FORMATION". *Medium brown dolomite.*

Upper half is barren, and shows a faint recrystallization texture, similar to that seen in overlying Watt Mountain. Moderately vuggy (fossil moldic????) Fairly abundant, disseminated argillaceous material.

Lower half contains fairly abundant, matrix supported, corallline debris, and some thick shelled brachiopods.

N.B. Lowermost contact somewhat uncertain, core jumbled??

34.7 – 46.9 BUFFALO RIVER "FORMATION".

34.7 – 35.7 G1 Shale. *Limy shale.*

Limy, medium grey shales. Fairly competent.

35.7 – 36.3 G B Marker Bed. *Dolomite.*

Upper half a medium brown, finely crystalline dolomite, with G1 "clasts" in upper few inches. Lower half unit cleans up, becomes greyer, and slightly limy.

36.3 – 39.0 G1 Shale. *Limy shale.*

Medium grey, limy shale. Very soft and clay like in part.

39.0 – 39.9 G3? *Argillaceous sandy dolomite.*

Somewhat similar to G5, but more wispily argillaceous.

39.9 – 41.5 G1 Shale.*Dolomitic shale.*

41.5 – 44.2 G3/G2 *Argillaceous dolomite.*

Predominantly silty/sandy textured, wispily argillaceous, medium brown grey dolomite. Nodular textured (G2), but dolomitic.

44.2 – 45.7 G1 Shale.*Dolomitic shale.*

45.7 – 47.9 Unknown – T.N.L.

46.9 – 76.2 PINE POINT FORMATION

46.9 – 61.0 E facies. *Dolomite.*

Typical light to medium brown, clean, porous, sandy dolomite. Fairly friable. Coral fragments occur sporadically. Unit is slightly B'ish in part, especially toward the base.

61.0 – 62.8 B Marine Dolomite. *Dolomitized biomicrite.*

Medium dark brown, wispily argillaceous/bituminous dolomite. Scatterings of brach. and crinoidal debris throughout. Very sharp upper and lower contacts.

62.8 – 70.7 E facies. *Dolomite.* More or less as above, slightly denser.

70.7 – 73.2 B Marine Dolomite. *Dolomitized biomicrite.*

Medium brown-grey, argillaceous dolomite. Disseminated argillaceous/bituminous matter throughout. Fairly abundant crinoidal debris, with occasional thin-shelled brachiopods.

N.B. Uppermost 30 cm, wispily argillaceous, fossiliferous, sandy textured dolomite. Possibly vestigal B.D.E. fossil horizon???

73.2 – 76.2 B Marine Limestone. *Biomicrite.*

Material much like that described above, with 30% beds of dark brown, more abundantly fossiliferous, more richly bituminous limestone. Brachiopods much more abundant.

E.O.H. @ 76.2 m

Cominco D.D.H. 4326

0 – 20.1 Casing/Overburden.

20.1 39.3 WATT MOUNTAIN FORMATION

20.1 – 21.3 Apparently the Blotchy member – but this seems to be from out of place boulders. There is no continuity of lithology here.

21.3 – 22.9 Upper Micrite member. *Micritic limestone.*

Classic light cream, vuggy, dense, finely crystalline limestone.

22.9 – 25.0 Upper Shale member. *Limy and dolomitic shales and marls.*

Bluish-green, dull, earthy in texture, dolomitic marl. Uppermost 30–60 cm is more of a wispy/flaser bedded limestone.

25.0 – 29.0 Silty Dolomite member. *Fine grained dolomite.*

Finely bedded, finely silty textured, porous dolomite. Quite friable for the most part – recovery thereby poor.

29.0 – 35.1? Lower Shale member.*Limy and dolomitic shales and marls.*

(Footage marker difficult to read here)

Typical, heterogeneous assemblage of blue-green marls, shales, and flaser bedded (cleaner) limestones, cream in colour, and dull in aspect. Unit is dolomitic to 32.2 m, and then limy to bottom. The uppermost metre or so, and continuing up into the Silty Dolomite member, is characteristically veined by gypsum, in displacive veins and veinlets (generally parallel to bedding), and lesser nodules, producing a chicken-wire texture.

35.1? – 39.3? Basal Marine member. *Limestone / dolomite.*

(No footage markers) Only the uppermost 60 cm or so is preserved as limestone, the remainder is dolomitized. A fairly light greyish brown, wispily laminated, finely crystalline, dense dolomite. Becomes darker with depth, and characteristic white dolspar blebs become more abundant. Thin blue-green-grey clay seams occur sporadically. These are especially abundant in lowermost 1–2 m.

39.3 – 43.9 B BIOSTROMAL "FORMATION". *Dolomite.*

Dark brown, dense, finely crystalline dolomite. Wispy for the most part. Upper half devoid of fossils, lower half is a floatstone, with fairly abundant digitate stromatoporoids. Lowermost metre or so is, again, relatively barren.

N.B. Recovery here is relatively poor, footages estimated.

43.9 – 49.4 BUFFALO RIVER "FORMATION".

N.B. 43.9 – 46.3, 1.0 m only recovered.

43.9 – 45.4? G1 Shale.*Dolomitic shale.*

Very little recovered. What is, appears to be more competent than usual – more of a wispy, silty textured argillite.?

45.4? – 46.3? G B Marker Bed. *Dolomite.*

(Probably preferentially recovered within this run – approx. 30 cm recovered.) Dark brown, dense dolomite. B Bio. like.

46.3? – 46.9 G3?/G2. Finely sandy textured, wispily argillaceous, vaguely nodular textured dolomite.

46.9 – 47.5 G1 Shale.*Limy shale.*

Soft, limy shale.

47.5 – 48.1 G3? *Argillaceous dolomite.*

A somewhat sandy/silty textured, wispily argillaceous limestone. Competent, with a somewhat disturbed texture – vaguely G2 like in part.

48.1 – 49.4 G5 *Wispy dolomite.*

Difficult to pick the base here. A medium grey, faintly wispy, sandy dolomite. Seems to "clean up" with depth, but becomes more distinctly wispy. Lower half hosts some large coralline debris.

49.4 – 76.2 PINE POINT FORMATION

49.4 – 51.2 B-E facies. *Wispy dolomite.* Distinctly wispy, sandy textured dolomite.

51.2 – 76.2 E facies.*Dolomite.*

Good clean, sandy textured dolomite. Partially presqu'ilized to 54.9 m.

E.O.H. @ 76.2 m

Cominco D.D.H. 4327

0 – 15.8 Casing/Overburden.

15.8 – 33.8 WATT MOUNTAIN FORMATION

15.8 – 17.4 Gritty member, for the most part, with some Blotchy member material mixed in.

17.4 – 18.9 Upper Micrite.

Micritic limestone.

18.9 – 20.4 Upper Shale member.

Limy and dolomitic shales and marls.

20.4 – 21.9 Lower Micrite.

Micritic limestone.

21.9 – 25.0 Silty Dolomite member.

25.0 – 32.6 Lower Shale member.(28.0 – 29.6 limy) *Limy and dolomitic shales and marls.*

32.6 – 33.8 Basal Marine member. *Limestone and dolomite.*

Patchily dolomitized – core may be jumbled?? No obvious break at base.

33.8 – 38.3 B BIOSTROMAL "FORMATION". *Fossiliferous dolomite.*

N.B. Run 35.7 - 38.7 has been reversed, such that there is apparently 30 cm of G1 shale from 35.7 - 36.0!!

Otherwise this is a quite normal, dense, wispy dolomite, hosting fairly abundant digitate strom., and thick shelled brach. debris The lowermost 1.0 m is apparently barren (and crackle brecciated).

38.3 – 43.3 BUFFALO RIVER "FORMATION".

38.3 – 38.7 G1 Shale.*Dolomitic shale.*

38.7 – 39.0 G B Marker Bed. *Dolomite.*

Much like upper B Bio., but there is no jumbling here, for top of

interval contains characteristic G1 "lithoclasts".

39.0 40.6 G1 Shale.*Limy shale.*

Soft, fissile, limy shales.

40.6 - 41.3 G3?/G2. *Argillaceous limestone.*

Wispily argillaceous, vaguely nodular textured, finely sandy, dense, grey limestone. Much more richly argillaceous than a G5. Contains rare corals.

41.3 - 41.6 G1 Shale.*Dolomitic shale.*

41.6 - 43.3 G5.*Dolomite.*

Light to medium grey, sandy dolomite. Wispy and disseminated argillaceous content. Minor corals and thick brachiopods.

43.3 - 76.2 PINE POINT FORMATION

43.3 - 44.8 E-B facies. *Dolomite.*

Somewhat transitional - could possibly be included in with G5.

44.8 - 76.2 (K)B-E facies grading into E facies.

E.O.H. @ 76.2 m

Cominco D.D.H. 4808

0 – 20.1 Casing/Overburden.

20.1 – 28.7 WATT MOUNTAIN FORMATION

20.1 – 22.6? Silty Dolomite member.

Fine grained dolomite.

22.6? – 26.5 Lower Shale member. *Limy and dolomitic shales and marls.* Dolomitic to 24.7 m. Distinctive birdseye textured grey limestone at basal contact with...

26.5 – 28.7 Basal Marine member. *Limestone.*

28.7 – 33.4 B BIOSTROMAL "FORMATION". *Fossiliferous dolomite.*

Upper half fairly dense, finely crystalline, medium to light brown dolomite. Wispy. Devoid of fossils until 29.6 m, whereupon digitate stromatoporoids and thick shelled brachiopods become fairly abundant. They are, nevertheless, matrix supported throughout.

N.B. Lowermost 60 cm is a little greyer in colour than normal.

33.4 – 38.4 BUFFALO RIVER "FORMATION". *Karsted.*

33.4 – 34.3 G1 Shale.*Dolomitic shale.*

34.3 – 34.9 G B Marker Bed.*Dolomite.*

34.9 – 36.9 G1 Shales (probably remobilized).

36.9 – 38.4 G5? *Grey sandy dolomite.*

38.4 – 76.2 PINE POINT FORMATION

38.4 – 44.2 *Karsted* K BRS facies.

44.2 – 48.8 (K)E facies.

48.8 – 57.0 *Karsted*........????

57.0 – 60.7 K D2? or bleached K BRS??? a bit odd.

60.7 – ? E facies.*Dolomite.*

Hole continues to 76.2 m, not logged at this time.

Cominco D.D.H. 4809

0 – 16.6 Casing/Overburden.

16.6 – 30.2 WATT MOUNTAIN FORMATION

16.6 – 18.3 Upper Micrite. *Micritic limestone.*

18.3 – 19.8 Upper Shale member. *Limy and dolomitic shales and marls.*

19.8 – 21.3 Lower Micrite. *Micritic limestone.*

21.3 – 22.9 Silty Dolomite member.
Fine grained dolomite.

22.9 – 28.0 Lower Shale member. *Limy and dolomitic shales and marls.*
(Upper half dolomitic.)

28.0 – 30.2 Basal Marine member. *Limestone and dolomite.*
(Upper half limy.)

N.B. 29.9 – 30.2 Green shale/clay band, with distinctive brown clay + rubble zone @ 30.2.

30.2 – 33.5 B BIOSTROMAL "FORMATION". *Dense, fossiliferous dolomite.*
Abundant digitate stromatoporoids., corals and brachiopods.

33.5 – 39.9 BUFFALO RIVER "FORMATION".
Very poor recovery throughout.

33.5 – 34.4 G1 Shale.*Dolomitic shale.*

34.4 – 34.7 G B Marker Bed. *Dolomite.*
Partially limy.

34.7 – 38.4 G1 Shale.*Dolomitic shale.*
Vaguely nodular textured in part.

38.4 – 39.9 G5 *dolomite.*> N.B. Last 30 cm here looks like G1 shale??

39.9 – 76.2 PINE POINT FORMATION

39.9 – 55.2 K BRS – E facies. *Dolomite.*

55.2 – ? K E facies to E facies.

Dolomite.

Hole continues to 76.2 m, not logged at this time.

Cominco D.D.H. 1815

0 – 15.8 Casing/Overburden.

15.8 – 21.3 WATT MOUNTAIN FORMATION

15.8 – 19.5 Lower Shale. *Limy shales and marls.*

19.5 – 21.3 Basal Marine member. *Light brown limestone.*

Green clay band at this contact.

21.3 – 24.1 B BIOSTROMAL "FORMATION". *Fossiliferous limestone / dolomite.* Richly fossiliferous – a packstone for the most part. Upper half limestone, lower half dolomitic. Lower half is also more brown in colour, approaching a floatstone in nature, and is more akin to the B Bio. as developed toward the north.

24.1 – 29.3 BUFFALO RIVER "FORMATION".

24.1 – 24.7 G1 Shale.*Dolomitic shale.*

24.7 – 25.6 G B Marker Bed.*Dolomite.* Massive and pancake stoms., and thick shelled brachiopods., in a greyish, sandy textued matrix. Very similar to "reefal" B Bio.

25.6 – 25.9 G1 shale.*Dolomitic shale / limestone.*

(Upper third competent and G 3'ish?

25.9 – 27.4 G3? *Sandy, argillaceous dolomite - karsted.*

27.4 – 29.3 G5 *Sandy dolomite - karsted.*

29.3 – 40.5 SULPHUR POINT FORMATION

K D2 / K SRF facies. *Fossiliferous dolomite.*

40.5 - 55.2 PINE POINT FORMATION

E.O.H. @ 55.2 m

Cominco D.D.H. 4349

0 – 15.2 Casing/Overburden.

15.2 – 18.0 WATT MOUNTAIN FORMATION

15.2 – 18.0 Basal Marine member. *Limestone.*

Pinkish beige limestone. Birdseye textures. burrows, and occasional large lithoclast. Last 15 cm is grey clay/shale.

18.0 – 23.0 B BIOSTROMAL "FORMATION". *Fossiliferous dolomite.*

Richly fossiliferous, "reefal" interval. Massive stromatoporoids, lacy corals, lesser brachiopods, and pancake stromatoporoids. 20.1 – 20.7 Greyer in colour, and contains abundant crinoidal material, with corals and brachiopods.

23.0 – 27.4 BUFFALO RIVER "FORMATION".

23.0 – 24.7 Interbedded grey shale, and sandy textured, bedded dolomites.

24.7 – 27.4 G5*Sandy dolomite.*

Strongly replaced by calcite veining and flooding – obscuring basal contact.

27.4 – 38.4 SULPHUR POINT FORMATION

K SRF – strongly replaced to 29.6 m

38.4 – 64.6 PINE POINT FORMATION

Not logged at this time.

E.O.H. @ 64.6 m

Appendix B

THIN SECTION DESCRIPTIONS

#A90 - 4322 - F facies (122.8m)

Extremely abundant, matrix supported, *Tentaculites* sp. and *Styliolina* sp. in a fine, dark brown, organic? rich micritic matrix. Tests are all oriented with long axes parallel to bedding. These flask shaped tests are extrememly well preserved – and are both smooth and corrugated in appearance. The interior of these tests was apparently sheltered from sediment influx, to be filled by a later sparry calcite. This has, for the most part, been recrystallized to a fine (0.05mm.) dolomite. Tests themselves appear to have been preserved as fibrous calcite. Inasmuch as both long and cross sections can be observed, with equal regularity, it would appear that there has been no current activity here to preferentially orient these tests.

Within certain horizons cricoconarids are so abundant that they may represent upto 75% of the total volume. However, on average they constitute only 5–10%.

Fine (0.05mm.) dolomite rhombs are sporadically developed within the otherwise uniform, dark, micritic matrix.

#A98 - 4640 - BML->F facies (95.4m)

Abundant cricoconarids and lesser thin-shelled brachiopod debris are found in a subplanar laminated, dark, micritic, matrix. Cricoconarids are, for the most part, matrix supported. Almost without exception they are oriented with their long axis parallel to bedding. Fossil material stands out in quite sharp relief against the matrix, being well preserved, and very little replaced. Furthermore, these delicate tests are preserved intact, and signs of breakage (from compaction or transportation) are absent.

The tests themselves are apparently preserved as calcite. Internal structure is very difficult to see, however the calcite is apparently fibrous, and arranged sub-parallel to shell surface (a very shallow angle) and appears to be somewhat

similar to brachiopod shell structure. These tests apparently acted as sediment shelters, and were filled by a clear calcite cement after deposition. This in turn has been prefentially dolomitized, and is now preserved as fine interlocking dolomite rhombs. Very rarely the original calcite cement is preserved and then only within larger specimens.

The cricoconarids are generally smooth walled and flask shaped (*Styliolina* sp.?). Occassionally the walls are more corrugated in appearance (*Tenatculites* sp.?). Punctate brachiopod fragments occur sporadically, also showing fibrous calcite structure. It is undulose in texture, and lies at a shallow angle to shell surface. These are all fragments of disarticulated shells, no greater than 0.5mm. in thickness.

The matrix here is extremely fine grained, and varies from light to dark chocolate brown in colour. It is apparently these colour variations which highlight the overall laminated texture. Fine (max. 0.05mm.) dolomite rhombs are peppered throughout this matrix. These rhombs are identical to those found within sediment sheltered areas. Their growth was apparently inhibited within the more organic rich matrix?

Elongate blebs of fine pyrite are sporadically developed within the matrix. Rarely, more euhedral forms can be seen replacing brachiopod and cricoconarid tests.

#A96 - 4641 - B(marine) facies (110.0m)

Both articulate and disarticulate brachiopods "float" in a fine biomicritic matrix. The matrix is wispy in part, with an overall medium to dark brown colour (from organic content?)

Fine (0.05mm.) dolomite crystals are developed throughout this matrix, but rarely occur in contact, one with the other. Instead, they are surrounded by dark, organic? material. Of notable exception are the interiors of (relatively rare) articulate brachiopods. They apparently offered some kind of shelter to either

sediment influx or hydrocarbon migration (or both), and were filled, post-depositionally, with a clear calcite cement. This, in turn, has been preferentially dolomitized to rhombs - again only 0.05mm. in size - but here in close proximity, one with the other. A similar sort of sheltering effect can occasionally be seen beneath disarticulated, upwardly convex valves.

Such large brachiopod shells rarely exceed 0.5mm. in thickness, and are apparently both punctate and impunctate. This suggests a variety of forms may be present such as *Atrypa* spp. or *Warrenella* spp. The fine bioclastic material, which in part comprises the matrix, is primarily brachiopod derived but presumably from thinner walled, more delicate specimens. Crinoid ossicles are also present, but are relatively rare in these examples. Cricoconarids are abundant throughout the matrix.

Fine pyrite is scattered sporadically throughout the matrix, concentrating along wisps, or laminae. It occassionally replaces shelly debris, and constitutes upto 2% of the section.

In 4323, some slender (5mm.) coralline debris (Thamnoporid???) can also be found. Original calcite cement has been preserved within the interstices. Bryzoan and/or algal debris can also be tentatively identified. The coarser bioclastic component of these samples comprises approximately 10% of the rock. This is probably slightly above average, but not unusual.

#A87 - 4640 - G-B lithofacies (92.6m)

(This sample taken just above B(marine) contact)
The majority of this section comprises a somewhat "cleaner" than usual, yet still organic rich, brown micrite. However all of the usual (for B facies) laminar textures have been destroyed, and the shelly debris present (cricoconarid predominantly) is quite randomly oriented. This in itself is suggestive of bioturbation, and is quite different from the clearly laminated texture seen in B and F facies samples.

Furthermore, several discrete, semi-concentrically laminated burrow like features (approximately 0.5cm. diameter) can be discerned. Light grey in colour, they are texturally similar to the matrix, but seem to lack the brown organic component entirely. Inasmuch as these are primarily distinguishable due to colour change, they could represent some kind of bleaching effect (guided by burrows?) or areas somehow protected from hydrocarbon influx.

This, then, is essentially a fine, bioturbated, biomicrite with only very minor signs of incipient dolomitization. Dark wisps of Fe sulphide concentrations occur sporadically, and apparently randomly.

#A85 - 4640 - G-B lithofacies (87.8m)

A quite distinctive thin section, containing very abundant subrounded peloids (avg. diameter 0.2mm.) They are quite densely packed, and for the most part, self-supportive. Dull, medium grey in colour, and extremely finely crystailine, they are generally featureless, but occassionally enclose fine pelmatozoan debris.

Broken brachiopod shells are quite common, and there is possibly some trilobite material. Crinoid ossicles are scattered rarely throughout, with lesser bryzoan and/or algal debris. The matrix here appears to be a neomorphically recrystallized micrite.

Fine patchy blebs of hydrocarbon staining obscure detail throughout. However, compared to B Marine and F facies, this is minor. Possibly it has been obstructed by the increased argillaceous content? Such organic material which does occur, patchily coats and rims fragments, and is found only within the matrix.

The peloids, descrbed previously, have a distinct coating of dark grey matter, no doubt argillaceous, and identical to the clay seen in *4640 G-B 292'*.

#A84 - 4323 - G-B lithofacies (110.9m)

Clearly nodular textured in hand specimen (irregular nodules upto 1.0cm in diameter) these are somewhat difficult to discern in thin section. They show no definite boundaries, and are essentially the result of preferred hydrocarbon migration through the "matrix"? In any event they are composed of essentially the sqme grey, argillaceous, biomicrite as the so called matrix, but lack the dark organic stain, which seems to concentrate along wispy partings. Aside from this differential coloration, the rock is very similar to all other G-B sections. Finely broken brachiopod debris predominates, with lesser crinoidal, bryzoan and/or algal fragments, in a fine, "dirty", matrix. The matrix is medium grey in colour, and shows a characteristic "felted" texture.

Bioclastic fragments are randomly oriented, and macro-texture is strongly suggestive of bioturbation.

N.B. "Organic" wisps become much darker at points of apparent highest compactional pressure i.e. where lumps are in close proximity, or near the ends of shell fragments also in close proximity. This results in the wisps seemingly splaying about these fragments.

Does this mean that:

1. Original uniform colouration and organic content is subsequently concentrated along discrete zones?

or

2. Organic migration was channeled along discrete zones i.e. pre-existing argillaceous partings?

If it is the latter (which seems the more likely) Then why are these "lumps" seemingly protected? Similarly with brachiopod interiors?

#A75 - 4334 - G5 lithofacies (44.5m)

A fine, dusky looking biopelmicrite? Small, dark grey, subrounded peloids are the most noticeable component, comprising upto 20% of the section. These peloids are all, apparently, coated with the grey clay, associated with all Buffalo River

samples, and are similar to the peloids seen in G–B lithofacies – except they are much smaller, with an average diameter of 0.05 – 0.1mm, as opposed to 0.3mm. Fine bioclastic debris is also abundant throughout this section, with a maximum diameter of 0.5mm. It is, however, difficult to identify, due to size, degree of recrystallization and the masking effect of the clay fraction. Nevertheless, much of this is of an apparent shelly origin, and some is either bryzoan or algal in nature.

This would appear to have been an originally grain supported sediment, but diagenesis has effectively obscured much original detail – particularly size and nature of original cement.

There is a concentration of hydrocarbon / bitumen along wispy / stylolitic partings.

#A64 - 4342 - G2 lithofacies (57.9m)

Macroscopically the G2 (nodular) texture is clearly visible. However, microscopically the boundary between the two is not nearly so well defined.

Texturally the two areas are very similar. However, the "matrix" is darker, and apparently contains an increased proportion of fine, felted to dusty looking grey clay. The "nodules", therefore, are cleaner, and fine detail is somewhat easier to discern.

Fine bioclastic debris is discernible (cricoconarids for the most part?, with lesser bryzoan &/or crinoidal matter). The apparent cricoconarid tests have a maximum diameter of 0.2mm, with a maximum test thickness of 0.02mm. The matrix here was apparently, originally, micritic, but has since been neomorphically recrystallized.

Scattered throughout are extremely fine, peloid–like features, roughly oval in shape, rounded in form, and extremely small average diameter 0.02mm. Approximately 20% of these forms have been entirely replaced by iron sulphide.

Fine (0.02 – 0.04mm) dolomite rhombs are scattered throughout the matrix. Within this matrix, clay particles are aligned into wispy laminae, which splay about nodules.

#A69 - 5557 - G B Marker bed (63.4m)

Dark chocolate brown in colour, wispily laminated, dolomitized biomicrite, containing one large, concentrically laminated nodule of G1–like composition. Rock has been extensively dolomitized, such that upto 60% vol. is composed of extremely fine (0.02mm) dolomite rhombs, scattered evenly throughout. However, even at their most dense packing, these rhombs are at all times separated, one from the other, by either a hydrocarbon film, or grey clay.

The majority of the rock is rich in hydrocarbon, and also contains abundant, thin (0.02mm) shelly debris of unknown origin. These tests are fairly large – upto 0.75cm in length, and are all oriented parallel to bedding. They appear to have been crushed by compaction, such that they have no interiors, to speak of. However, when an interior is preserved, it has invariably been protected from bitumen influx.

The grey, nodule–like, feature is composed of a relatively featureless, dolomitized, argillaceous micrite? It is devoid of hydrocarbon stain – perhaps because of protection by the enhanced clay content??, and is similarly devoid of both wispy laminae and organic debris.

#A61 - 4334 - Reefal facies (42.4m)

This is a very attractive section, for it is a quite well preserved, coarse, packed biosparite.

Fossil debris is diverse, and abundant. It includes large, thick–shelled (upto 1.0mm) brachiopods, thamnoporid coral fragments (upto 1.0cm in diameter),

stromatoporoids, and abundant crinoidal debris, including plates and spines. While debris in excess of 1.0mm predominates, finer material generally fills in all the gaps. Fine subrounded peloids (0.05mm) and lumps also occur within this matrix. Fossils here are entirely self-supportive, and are healed by a sparry cement.

There is very minor hydrocarbon infiltration along small wispy partings - entirely secondary in nature. These partings are generally accompanied by signs of (minor) pressure solution.

#A46 - 4340 B Biostromal facies (39.3m)

This rock has been entirely recrystallized to a fine rhombic dolomite, with crystals of 0.05mm average diameter. Crystals are loosely interlocking, but are all surrounded by a hydrocarbon film (dark amber brown in colour). This stain is vaguely concentrated along wispy-like features, sub-parallel to bedding.

Extremely ghosted, coarse bioclastic material is occasionally discernible. Apart from a few obviously shelly fragments, this is impossible to identify. Such "ghosts" are distinguished by the coarser dolomite crystals developed within, which are more tightly inter-locking, and which thereby contain a reduced hydrocarbon fraction.

#A42 - 4341 - Restricted facies (41.7m)

Biomicrite. Fine, delicate, shelly matter, in an extremely fine grained, medium grey, felted textured groundmass. Foraminiferal and ostracod tests predominate. All such material is apparently randomly oriented, and matrix supported.

Minor, and patchy, hydrocarbon permeation has occurred, associated primarily with distinctive, elongate, dolspar filled cavities. These features show sharp margins, with no sign of any wall alteration, and are filled by coarse dolomite. Such features are 1-2mm in diameter on average, and upto 5.0mm in

length. Their orientation shows a preference toward the vertical.

The extremely fine grained nature of the rock makes further observations difficult.

#A40 -4337 - Restricted facies transitional to Lower Shale Member (33.2m)

A birdseyed textured pelmicrite (matrix neomorphically recrystallized in part).

A classically textured rock, for the most part, with fine, somewhat irregular, peloids in a micritic matrix. This material has been disrupted into sub-rectangular lumps, by the development of the rather irregular birdseyes (sub-parallel to bedding and spar filled). These distinctive cavities comprise upto 30% of the rock, and are associated with fine (algal?) laminations features which apparently bound the rock together. This is more clearly demonstrated toward the base of the slide, where a distinctive, somewhat peculiar texture is developed, in a 2.0mm wide pelsparite bed. The peloids, here, show a distinctive upward graded bedding, and are capped by a 0.5 - 1.0mm thick, crinkly laminated, and distinctly algal, bed.

With the possible exception of this graded interval, all of the spar in this sample appears to be either neomorphic in origin, or a later stage cavity filling. The original rock was apparently an extremely fine-grained, light-medium grey, dusty textured pelmicrite.

#A36 - 5557 - Lower Shale member (46.6m)

An extremely fine grained, intraclastic micrite.

The section has an overall dusky texture, which effectively obscures fragment boundaries. Furthermore, there is very little contrast between intraclasts and matrix, rendering definition poor.

Distinctly wispy (argillaceous?) partings, with a horsetailing habit, are developed throughout.

#A26 - 4341 - Silty Dolomite member (33.5m)

An extremely fine-grained, equigranular dolomite. Entirely homogeneous, and virtually featureless, except for distinct bedding laminae, which might possibly relate to very slight variations in grain size, and thereby colour.

#A25 -4317 - Lower Micrite member (39.9m)

An extremely fine-grained, dull, homogeneous micrite. Virtually featureless, except for hydrocarbon stained stylolites, and distinctly angular, rhombic to lath shaped, cavities occassionally filled with calcite. These are interpreted as gypsum molds, or pseudomorphs.

#A19 - 4323 - Upper Micrite member (48.5m)

Absolutely identical to the Lower Micrite described above.

#A22 - 4323 - Upper Shale member (50.9m)

An extremely attractive section. Abundant charophyte oogonia occur throughout, their interiors frequently filled by a single dolomite crystal. These charophytes occur in an intraclastic limestone matrix. The matrix material, itself, is extensively replaced by fine dolomite rhombs (generally less than 0.02mm in diameter). The intraclasts are themselves rather small, being in the 0.2 – 0.5mm range, and

rarely exceeding 1.0mm in length. They are quite irregular in shape and size, and are at times subangular in form: this would seem to discount a peloid affinity.

#A15 - 4317 - Gritty member (34.4)

Biointramicrite. An an extremely attractive, distinctive section. Somewhat similar to the sections described from the Upper Shale, for it, too, contains both intraclasts and charophyte oogonia. The charophytes are similar, in both appearance and abundance (3 – 5%). Nevertheless, this section is much more distinctly, and coarsely intraclastic.

Such intraclasts are micritic in nature, rectangular in form, subangular, and generally in excess of 1.0mm in length. Fragments upto 0.5cm are not uncommon.

These intraclasts, (which lend the rock its "gritty" texture), together with the charophyte oogonia, 'float' in a more finely intraclastic, micritic matrix – which, in this instance, shows the development of dolomite rhombs, peppered throughout.

#A6 - 4317 - Blotchy member (27.4m)

Biointramicrite. An extremely finely intraclastic section, containing scattered charophyte oogonia, and showing a distinctly (finely) laminated texture – apparently algal in origin. These laminae are faintly enhanced by hydrocarbon stain, and by iron sulphide speckling. It is this which lends the rock its fine blotchy texture – in this instance very faintly developed, distinctly parallel to bedding. (This is not the blotchy texture referred to as "spitfire texture", but is more of the finely bedded variety.)

Texturally somewhat similar to sections of the Gritty and Upper Shale members, this interval is, however, considerably cleaner in nature. It is also finer grained, and is, in part at least, distinctly laminated.

#A13 - 5557 - Amphipora Marker bed (24.4m)

Biointramicrite. once more, this section is distinctly, and fairly coarsely, intraclastic. However, it is also quite richly fossiliferous, containing amphipora (2.0mm diameter, in excess of 1.0 cm apperent length) and some fine shelly debris (brachiopod?). Such fossiliferous material is quite densely packed within a wispy, intraclastic matrix, which evidences considerable hydrocarbon stain.

#A3 - 4318 - M3 lithofacies (24.4m)

Biomicrite. Richly fossiliferous limestone. Large stromatoporoid fragments, with extremely well developed oncolitic rims, and "disposessed" oncolitic rinds, in a bioclastic matrix, in which shelly fragments predominate. Both ostracods and brachiopods appear to have been contributors. The matrix is extremely wispy, dark brown in colour, and apparently, once more, hydrocarbon permeated.

The algal laminated rims to the larger fragments do, themselves, contain some shelly debris, no doubt caught up in the (sticky) oncolitic growth process.

Appendix C

PLATES

Plate 1.

REPRESENTATIVE LITHOLOGICAL SAMPLES, WATT MOUNTAIN FORMATION.

Figures 1, 2 & 3. *Blotchy member.* 1. Typical blotchy (or "Spitfire") textured limestone. Texture enhanced by fine iron sulphide disseminations. 2. Sample shows development of both blotchy and finely intraclastic texture. Note presence of charophyte oogonia. 3. Sample typical of less strongly textured interval.
Figure 4. *Amphipora Marker Bed.* Abundant amphipora, and lesser bulbous stromatoporoids, in a fine, micritic, matrix. Note patchy hydrocarbon staining.
Figure 5. *Gritty member.* Characteristic, finely intraclastic limestone. Darker specks are charophyte oogonia.
Figure 6. *Upper Micrite member.* Typical, clean, light, stylolitic limestone, showing cellular style vugginess.
Figures 7 & 8. *Upper Shale member.* Examples from more competent horizons, showing coarsely intraclastic nature, and wispy argillaceous partings.
Figure 9. *Lower Micrite member.* Clean, light, micritic limestone. Stylolitic, with characteristic cellular style vugginess.
Figures 10, 11 & 12. *Silty Dolomite member.* 1. Fine grained dolomite, showing finely laminated nature. 2. Interbedded with nodular gypsum. 3. Note extremely well developed porosity (here, somewhat enhanced by leaching).
Figures 13 & 14. *Lower Shale member.* Samples from more competent, less argillaceous, horizons. Note characteristic horsetailing wisps, and extremely well developed birdseye texture.

Scale as shown.

Plate 1

Plate 2.

REPRESENTATIVE LITHOLOGICAL SAMPLES, "UPPER" SULPHUR POINT FORMATION.

Figures 1, 2 & 3. *Restricted facies.* Fine, micritic, limestone. Note faint bedding lamination (1), ostracod fauna (2), and sub-vertical boring features (3).

Figures 4 & 5. *B Biostromal facies.* Dense, finely crystalline dolomite. Note distinctive, bioturbated? texture, and paucity of fauna. Typical of "upper" B Biostromal facies.

Figure 6. *B Biostromal facies.* Abundant tabular stroms, thamnoporid corals and thick-shelled brachiopods. Typical of "lower" B Biostromal facies.

Figures 7 & 8. *Reefal facies.* Massive stromatoporoids, fairly well preserved.

Scale as shown.

Plate 2

Plate 3.

REPRESENTATIVE LITHOLOGIC SAMPLES, BUFFALO RIVER MEMBER, PINE POINT FORMATION.

Figure 1. *G1 lithofacies.* Typical, soft, fissile, limy shale.

Figures 2 & 5. *G B Marker Bed.* Transitional into overlying G1 (shale). Typical dense, fine grained dolomite, containing numerous G1 "nodules". Note crinoidal debris in overlying "shale".

Figures 3 & 4. *G2 lithofacies.* Nodular texture not especially well developed here. Note competent, fine grained, nature and minor fossiliferous debris.

Figures 6, 7 & 8. *G5 lithofacies.* Fine, bioclastic dolomite. Figures 6 & 7 show typical appearance. Figure 8 illustrates unusually coarse, bioclastic interval.

Figures 9 & 10.*G-B lithofacies.* Note swirling, bioturbated and burrowed texture, and overall darker colouration.

Scale as shown.

Plate 3

Plate 4.

All magnifications x60.

Figure 1. *Polygnathus ansatus* Ziegler et al., oral view. UA 7081. From sample 3030, G–B lithofacies, D.D.H. 4323. Figure 2. *Polygnathus timorensis* Klapper et al., oral view. UA 7082. From sample 3030, G–B lithofacies, D.D.H. 4323. Figure 3. *Polygnathus xylus ensensis* Ziegler et al., oral view. UA 7083. From sample 3043, G–B lithofacies, D.D.H. 4641. Figure 4. *Polygnathus alveoliposticus* Orr & Klapper, oral view. UA 7084. From sample 3030, G–B lithofacies, D.D.H. 4323. Figure 5 & 6. *Polygnathus linguiformis linguiformis* forma gamma Bultynck, oral views. 5, UA 7085 and 6, UA 7086. Both from sample 3037, G1 lithofacies, D.D.H. 4640. Figure 7. *Polygnathus linguiformis linguiformis* forma delta Bultynck, oral view. UA 7087. From sample 3023, F facies, D.D.H. 4322. Figure 8. *Polygnathus* aff. *P. dubius* Hinde, oral view. UA 7088. From sample 3037, G1 lithofacies, D.D.H. 4640. Figure 9. *Icriodus difficilis* Ziegler et al., oral view. UA 7089. From sample 3043, G–B lithofacies, D.D.H. 4641. Figure 10. *Icriodus brevis* Stauffer, oral view. UA 7090. From sample 3027, G B Marker Bed, D.D.H. 4323. Figure 11. *Icriodus nodosus* sensu lato Huddle, oral view. UA 7091. From sample 3021, G B Marker Bed, D.D.H. 4323. Figure 12. *Polygnathus* aff. *P. brevilaminus* Branson, oral view. UA 7092. From sample 3002, M3 facies, D.D.H. 4317. Figure 13. *Polygnathus* aff. *P. brevilaminus* Branson, aboral view. UA 7093. From sample 3002, M3 facies, D.D.H. 4317.

Plate 4